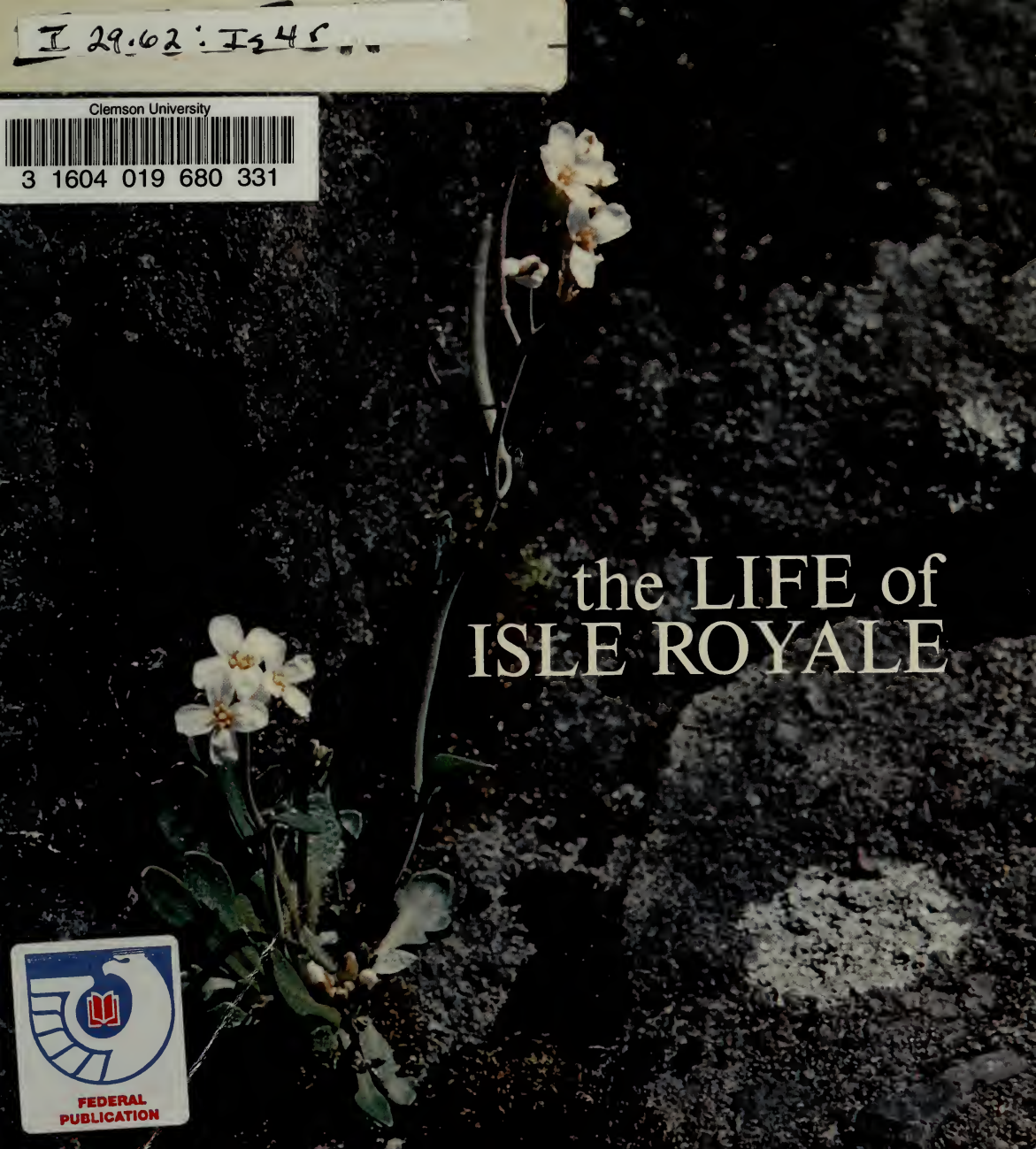

Natural History Series

the LIFE of ISLE ROYALE

by Napier Shelton

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Preface

This book is a natural history of Isle Royale for the layman. It emphasizes the ecology of the island—that is, the relationships among its plants, animals, and physical environment—rather than the characteristics of individual species. The human history has been viewed largely from the standpoint of its impact on the land. The book has been written in a way that we hope will benefit armchair travelers as well as those fortunate persons who actually visit the island.

Scientists have been studying Isle Royale since the mid-1800's, and I have read and learned much from their reports. Current students of the island have been particularly helpful. I would like to thank Dr. Robert Janke and Rolf Peterson, both of Michigan Technological University, for valuable information in the field and for reviewing the text; Dr. Durward Allen, Purdue University, for reviewing; Dr. D. B. Botkin and his research assistants, Yale University, for information in the field; Dr. Peter A. Jordan, co-leader of the Yale group, for a very helpful criticism of the manuscript; and Dr. N. King Huber, U. S. Geological Survey, and Dr. H. E. Wright, University of Minnesota, for reviewing chapters 2 and 3.

Robert Johnsson, of the National Park Service's Division of Museums, a former seasonal naturalist on Isle Royale, has contributed extensively to this book. I greatly appreciate his advice, his oral and written accounts of the island's natural history, the use of his photographs, and his generous support of the project.

Members of the Isle Royale National Park staff were especially helpful with the logistical aspects of my research for the book. I extend thanks particularly to Alan Eliason, Assistant Chief of Interpretation and Resource Management; Superintendent Hugh P. Beattie; and District Ranger Frank Deckert and his wife Gloria, who for two weeks shared their home with me and my family.

—N.S.

The Life Of Isle Royale

Arrival

"There it is!" someone exclaims. Rousing from a half-sleep, we part the curtains and look north across the wide gray waters of Lake Superior. Along the horizon floats a thin, dark strip—indistinct, almost a part of the water. From this point, halfway across the world's greatest lake in the lounge of the gently rolling *Ranger III,* Isle Royale is pure mystery.

We doze occasionally, and each time we awaken that thin line has stretched and widened. Finally we join the growing group on the deck. Like everyone else, we wonder what that remote island is like and what it holds in store for us.

As the vessel approaches Middle Islands Passage, the island begins to reveal itself. We see long outcroppings of gray rock. We see thick forest, pale green with birches and dark with the spires of spruce and fir. Across the water drifts the faint pungency of those firs, saying, as nothing else can, "North Woods." Entering Rock Harbor, we see the dark rocks along the shore, taking the lake's pounding below and wearing a band of orange lichens above the waves' reach. Herring gulls wheel against the backdrop of forest, rock, and sky. Ducks patter away at the vessel's approach.

But there are few clues to what is happening on this great, forested rock—the unfolding of petals under the trees, the burgeoning of young life, the deadly game between predator and prey. And there is hardly a hint about what it will be like to live on this wild island for the next small part of our lives.

To step onto Isle Royale is to leave behind one's old self and one's old world and to begin a new exploration into the nature of life.

We Stand On The Past

Early in our visit to Isle Royale we set out to climb up through the enclosing forests to a ridgetop, from where we can see the lay of this island and try to grasp it whole. After making camp at Daisy Farm on Rock Harbor, we start up the Mt. Ojibway Trail. Spruces, firs, and birches rise above us. For a little stretch our feet slip on rounded stones. Up the south side of Ransom Hill, where the forest opens and the trail steepens, we breathe a bit harder. Down the hill's more abrupt north side, where the white columns of paper birch surround us, we apply the brakes a bit. Now our boots thump on the simple bridge across Tobin Creek, which has been widened and deepened by a dam built by beavers somewhere downstream. Then up and over another hill, across the outlet of Lake Ojibway, and we make a longer climb toward Mt. Ojibway, a promontory of Greenstone Ridge. The forest thins, clumps of small maples appear, and as we gain the smooth-rocked grassy top of Mt. Ojibway and ascend the fire tower, the island opens before us. We see a strikingly striated pattern of land and water—

elongated, parallel forms that might have been created by a giant comb raking the emergent rocks in a northeast-southwest direction. Parallel ridges, dominated by the island's backbone—Greenstone Ridge—state the theme most boldly. Where the ridges reach Lake Superior they continue underwater, sometimes emerging to form narrow islands. The long, linear troughs between ridges hold here and there a stretched-out lake; and where the valleys reach the big lake they form long, deep coves. Plant distribution accentuates this parallel pattern. Light green aspen and birch dominate many ridges, while dark green coniferous forests lie in the troughs. Stretching along some ridgetops are open strips of grass and shrubs, through which the underlying rock mass often outcrops. Fifteen miles to the north, the mesa-like shapes of Thunder Cape rise along the Canadian shore, close to but irrevocably separated from the island by the cold, plunging depths of Lake Superior.

The Amygdaloid Island region of the park strikingly displays the ridge-and-trough topography of the archipelago.

All of it—the hills we sweatingly crossed, the forest scenes we glimpsed, the overall pattern itself—is the legacy of past events. The varying composition of the forest has been dictated by the topography, shaped slowly over eons by forgotten fires, by storms of yesteryear, by centuries of animal activity, and by a thousand little colonizations and extinctions during the island's history. The stones we slipped on near the start of our hike are an ancient beach formed by an ancestor of Lake Superior. The island's lakes owe their existence to great, gouging glaciers that thawed only a tick of geological time ago. And our legs ache today because the processes that formed and eroded the rocks millions of years ago created a corrugated topography.

The surface scene that spreads before us—lakes, forest, and the life-giving soil—is the work of 11,000 years, a very short time by nature's standards. During those one hundred and ten centuries the island appeared from beneath glacial ice; rose as the lake level dropped; was colonized by plants and animals; developed a little soil and a heavy, ever-changing forest; and experienced the beginning and inevitable shrinking of its many inland lakes.

Yet the creation of the rocks and the development of their ridge-and-trough pattern are the work of millions of years—a span of time in which the formation of Lake Superior and its islands is only the most recent event. The earth's oldest rocks, representing seas and mountains that gradually appeared and disappeared, lie thousands of feet beneath the thick deposits that make Isle Royale. The island's rocks date from a later episode, the formation of the Superior Basin, which was to shape all subsequent geologic events in the region.

Some 1.2 billion years ago, the earth's crust cracked along a great rift zone that stretched through the middle of the area now occupied by Lake Superior and may have bent southward toward the present Gulf of Mexico. Through this series of cracks poured molten lava, forced up by pressures deep within the earth. A hundred times or more, flaming sheets flowed out from the fissures, eventually covering thousands of square miles. As they did, the land along the rift zone sank, forming a basin. In the quiet periods between flows, rock material was washed from the rim of this great basin toward its center. After the last eruption, streams continued to carry boulders, pebbles, sand grains, and fine silt from the rim hills down toward the still-sinking basin plains. These events left a rock record consisting, beneath, of thick layers of volcanic rock alternating with thin layers of sandstone and conglomerate (composed of rounded rock fragments cemented together by finer material), and above, of several thousand feet of the last two types of sedimentary rock. These rocks—volcanics, sandstone, and conglomerate—form the bedrock of Isle Royale, with the volcanic basalt predominant on most of the island and the reddish sedimentaries forming the surface in the Feldtmann Ridge–Big Siskiwit River area. The arrangement of these rocks in layers and their differing

resistance to erosion dictated the island's present ridge-and-valley topography.

Some time after these layers were deposited, new pressures in the earth forced hot, mineral-bearing solutions up into the cavities and cracks in the rock. One of the minerals thus deposited was copper. Occurring in its pure, or "native" state, the veins and masses of copper lay within the rock, until the far-distant time when man would come hunting it. Those who walk the island's narrow pebble beaches can see other minerals—such as quartz; white, red, or yellow heulandite; white or yellow stilbite; and banded agate—which filled gas bubbles within the basalt and eventually were broken free by the pounding waves.

Molten rock forced between layers of dark basalt formed light-colored dikes like these at Conglomerate Bay.

Some time, also, after formation of the Superior Basin, faulting—displacement along a crack in the earth's crust—occurred, thrusting some sections of it upward and adjacent sections downward. One of these faults ran along what is now the center of the Keweenaw Peninsula, on the Michigan shore. Another is thought to have opened along the north edge of Isle Royale, which would account for the present projection of this piece of land above Lake Superior. Lesser faults cracked across the island, forming such depressions as McCargoe Cove and the valley that is followed by a section of the Huginnin Cove Trail.

Between the deposition of Isle Royale's uppermost conglomerate and the work of the most recent glacier there is an enormous gap in the geologic

Since the last glaciation, Isle Royale has gradually been emerging from lake waters as the land rebounds from its depressed state under glacial ice and the ancestral Great Lakes cut successively lower outlets. Figure 1 shows the position of the glacier's edge (dotted line) about 11,000 years ago, with the exposed western end of the island shown in brown. The gray area represents the present extent of Isle Royale. Figure 2 shows the island about 10,500 years ago, during the Lake Minong stage. By 5,000 years ago (figure 3), in the Lake Nipissing stage, Siskiwit Lake (on the south shore) had been cut off from the big lake and the island had nearly reached its present configuration. At the rate of a foot or more per century, the land continues to rise today.

figure 1. 11,000 years ago

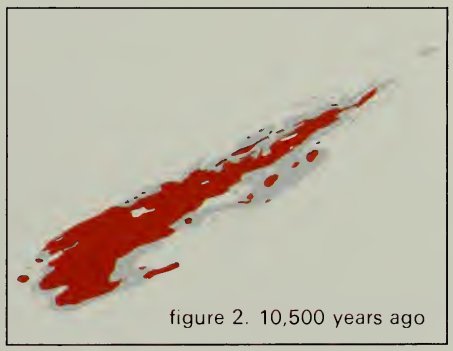
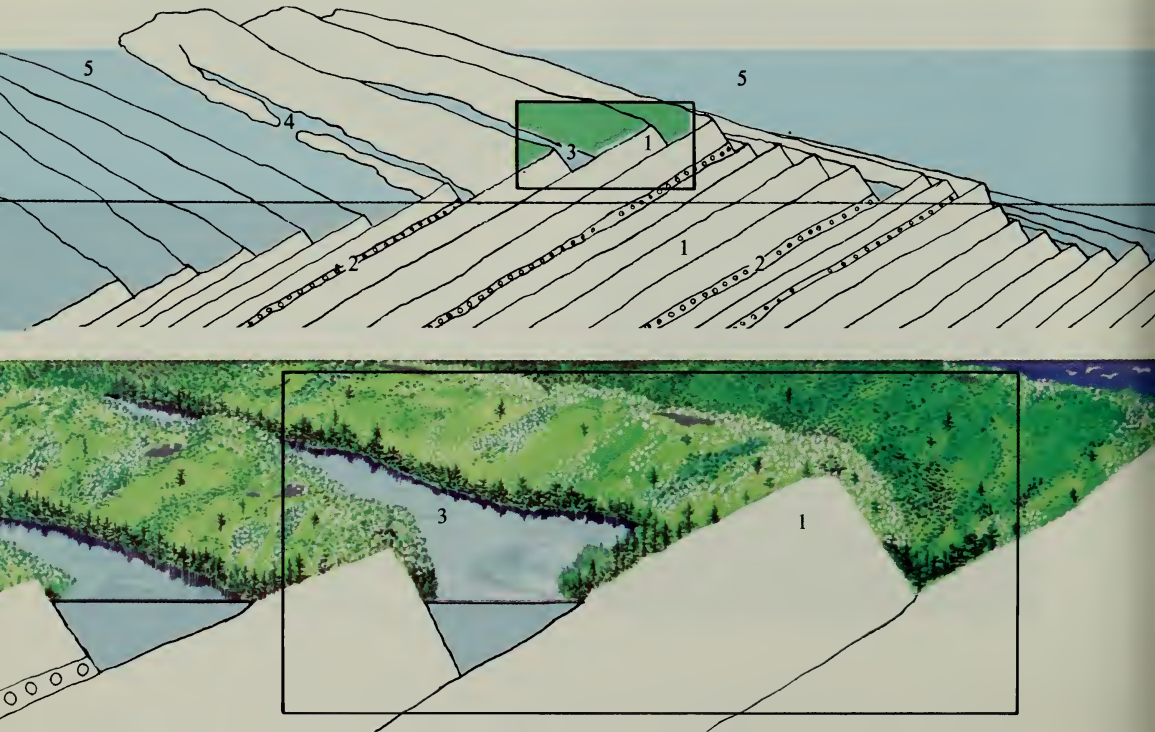


figure 2. 10,500 years ago

figure 3. 5,000 years ago

McCargoe Cove occupies a depression formed by a diagonal fault in the northeast part of Isle Royale.

Geologic events have strongly shaped the present character of Isle Royale. A series of lava flows, beginning some 1.2 billion years ago, formed the predominant rock of the island (1). During quiet periods between flows, sand and gravel were deposited in the subsiding Superior Basin and now form thin layers of sedimentary rock (2) between the lava flows. Subsidence in the basin's center produced tilting of the layers near the rims; on Isle Royale the rocks dip southeastward at angles ranging from 5 to 50 degrees. Erosion, particularly of sedimentary rock, between the uptilted lava layers produced the long valleys that alternate with the ridges of Isle Royale. In some of these valleys, glacial scouring left depressions that filled to become lakes (3). Coves and harbors (4) occupy low-lying troughs, and still other rock layers lie beneath the waters of Lake Superior (5), perhaps eventually to be raised high enough to become new offshore islands or peninsulas. Walking across the island, you will notice that the north sides of ridges—the edges of rock layers—are decidedly steeper than the south sides, which follow the more gentle dip of the strata. Through its influence on soil and moisture conditions, the regular ridge-and-valley topography has strongly affected the pattern of vegetation and with it the distribution of animal life. Thus the nature of Isle Royale's rocks has touched all aspects of the island's natural history.



record. Whatever deposits were laid down during those millions of years were subsequently eroded away, leaving the layers we have described to form the land's surface. Depressed in the center of the Superior Basin, these layers rose toward the basin's rim, where their edges were exposed in parallel bands. The bands of sandstone and conglomerate, being less resistant than the volcanic basalt, eroded faster. Streams tended to flow along the depressions started in these more vulnerable rocks, gradually deepening them. In this way, Isle Royale's bands of basalt remained higher to form ridges, while valleys developed on the sandstone and conglomerate between them. The south slopes of ridges remained fairly gentle, following the dip of the layers toward the center of the basin, while north slopes—the eroded edges of layers—dropped off steeply.

This pattern was accentuated and somewhat modified by the series of glaciers that rode down over the northern United States during the last million years. A cooling trend, accompanied perhaps by greater wetness, produced more snow across Canada during the winters than could be melted during the summers. As the snow accumulated, it was compressed into ice; and under pressure of the growing mass it finally began to move. Four major advances of these continental glaciers, separated by long intervals of mild climate during which the ice sheets melted, scoured the land as far south as the Ohio River. A large river

Looking north toward the central high part of Isle Royale, we see Siskiwit Bay, a large body of water that freezes over in calm winter weather. The contours of Houghton Point, in the foreground, reflect the geologic origins of the Isle Royale archipelago.

valley is thought to have occupied the center of the Superior Basin during the glacial period and to have channeled the immensely thick lobes of ice flowing through that area. The last major glaciation, known as the Wisconsin, ended in the Superior area only a few thousand years ago, leaving behind the ancestral Great Lakes, thousands of smaller lakes, and deposits of rock debris the glacier had scraped up and pulverized in its crushing advance.

Today on Isle Royale we can see many places where the ice, perhaps a mile thick, smoothed and rounded the rock, and other places where, pushing boulders over the bedrock, it carved long grooves. Running generally northeast-southwest, these grooves indicate that the glaciers moved mostly parallel to the ridges. Scouring the valleys deeper, the ice made depressions where lakes formed after its retreat. On the southwestern part of the island, where the last glacier paused in its retreat, are small, linear hills made of its deposits.

The dying of the last glacier led to the birth of modern Isle Royale. As it melted northward across the Superior Basin, which it had scoured and depressed, the ice formed a gigantic dam for its own meltwater, thus creating the first ancestor of Lake Superior. About 11,000 years ago, the ice front lay across the southwest end of that section of land we now call Isle Royale, leaving three-fourths of it buried under ice and the southwest quarter partly above and partly beneath the water. The shoreline then stood at about the present 800-foot contour. After a long pause at this position, the ice resumed its rapid retreat northward, leaving a thin mantle of deposits on the southwest end, where melting had been very slow, but very little material on the central and northeast sections, where melting had been rapid.

What did our island look like, newly relieved of its ice burden some 10,800 years ago? Studies by geologist N. King Huber indicate that about half of present-day Isle Royale projected above the water. Much of the southwest end was in one piece, but the northeast end tailed off to a long, thin peninsula flanked by island chains. Glacial till of sand, silt, and stones softened the contours on the southwest part and covered most of the bedrock, but toward the northeast most of the rock was exposed.

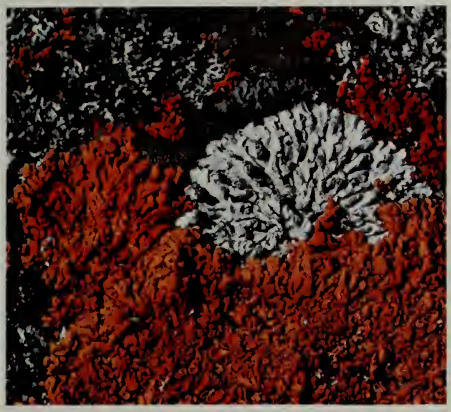
Like earth before primeval life, Isle Royale stood barren, waiting.

Life Comes To The Island

At the time of Isle Royale's birth, many forms of life were pressing northward as the warming climate rapidly destroyed the ice and exposed the land. Which ones first crossed the water to those smooth gray rocks, pounded by frigid waves, and to those bare, sandy hills?

Then as now, the wind and water carried spores and fragments of algae and lichens, and some of these settled on the new surface. Algae gained a foothold in wet places, and lichens pioneered mostly on rock, wet or dry. The air, the lake waves, and perhaps also wandering birds carried seeds of higher plants from the forests and grasslands south of the ice border. Some of these seeds—those from plants best adapted to cold, sterile conditions—germinated and grew on thin glacial deposits or in cracks in the rock.

Quite likely, many of the early colonists were tundra plants, of species now found only in the Arctic or on high mountains. Gradually these grasses, sedges, dwarf birches and willows, and other low-growing plants wove a green



Lichens, the first plants to become established in a new, rocky environment, help prepare the way for mosses, ferns, and eventually flowering plants such as bluebell or three-toothed saxifrage.

< Spiders, by virtue of their abundance and variety, have important roles as predators in most terrestrial communities.

carpet over the gray-brown hills, except in the many places where rock still resisted. Perhaps here and there, in sheltered spots, spruce trees grew.

Where there is plant food, animals can follow, and no doubt the vanguard was not long in coming. Airborne insects and microscopic animals drifting down upon the greening landscape now could survive. Birds could begin nesting here. A few caribou may have arrived across the lake's winter ice. Close on the heels of the plant eaters came animals that preyed upon them, including insects, spiders, hawks and owls. If there were caribou, wolves may well have braved the 15-mile ice crossing to hunt them.

On the Isle Royale of 10,500 years ago, we can imagine a scene much like that of the subarctic today. Mats of grasses and bright flowering little plants cover the ridgetops; shrubby birches and willows fill the draws; and down in the wet valleys scattered spruces raise their dark spires. Small bands of caribou, pausing frequently to scan the landscape for wolves, move up the hillside, browsing shrubs and nipping ground plants. But this is a transi-


Lake Superior
CANADA
UNITED STATES
Todd Harbor
Hatchet Lake
GREENSTONE RIDGE
Huginnin Cove trail
Huginnin Cove
Mount Desor
Lake Desor
MINONG RIDGE
Greenstone Ridge trail
Siskiwit Lake
Malone Bay
Washington Creek
Little Siskiwit River
Washington Harbor
Windigo
RED OAK RIDGE
Sugar Mountain
Island Mine trail
Siskiwit Bay
Grace Island
Grace Harbor
Feldtmann Lake
Big Siskiwit River
Point Houghton
Washington Island
FELDTMANN RIDGE
Lake Halloran
N
0 Miles 5
0 4 8
Kilometers

Campground; Ranger station;

Food; Lodging.

Green areas: sugar maple and yellow birch dominant.

Yellow areas: yellow birch dominant.

Orange areas: spruce-fir, paper birch, or aspen dominant.

tory scene in the story of Isle Royale; for the forest is coming.

As the ice retreated, the land, relieved of its great burden, slowly rose. The basin's waters, also lifted somewhat by the rising land beneath, flowed out through the lowest available outlet. Over the centuries, the trend was for land areas to rise higher above the water level, as downcutting and escape through successively lower outlets generally resulted in lowering the elevation of the water surface.

By about 10,500 B.P. (before present), the glacial ice had receded to the northern edge of the Superior Basin, which was then occupied by Lake Minong. This lake, which emptied by way of the Au Train-Whitefish strait (Munising, Michigan, area) and St. Marys Strait (Sault Ste. Marie area), remained stable for many years, thus building well-defined shorelines which are easily traced today. On Isle Royale, Lake Minong shore features are found at elevations of about 680 to 765 feet. (Subsequent uneven uplift accounts for the variation.) They include beach ridges (just west of Siskiwit Bay one is followed by the Feldtmann Ridge Trail), sea cliffs, and sea stacks. Of the latter, Monument Rock, on the Lookout Louise Trail, is the most spectacular.

As North American climates continued to warm and the continental ice sheets melted further, vegetation changed accordingly. On Isle Royale, spruce gradually took over, first forming scattered open groves and later, dense forests. Following soon came smaller amounts of pine, fir, aspen, and paper birch. With the establishment of these species, the forest must have looked much like the dominant forest on Isle Royale today.

And what of its animals? Many of these, too, were species present now. In the Great Lakes forests 9,000 years ago roamed marten, fisher, wolverine, lynx, snowshoe hare, beaver, muskrat, porcupine, wolf, woodland caribou, and moose, to name some of the larger ones. But which of these swam, rafted, or crossed the ice to Isle Royale we have no fossil record to tell us. It is tempting to imagine mastodons here, but these great beasts apparently preferred open rather than closed forests, and by 9,000 B.P. they were nearing extinction. The island's complement of insects and birds probably included many of today's. In the shore waters swam trout, herring, and whitefish, cold-

water species that had been able to survive near the glacial front.

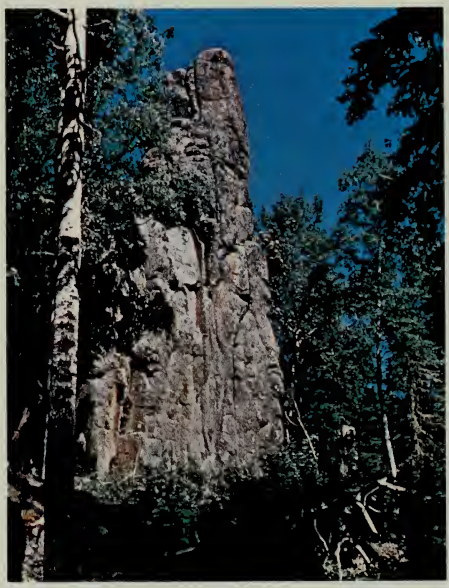
The warming trend that forced the retreat and eventual disappearance of the continental ice sheets reached a climax some 6,000 years ago. The climate then was warmer and drier than now, and prairie grasslands displaced forests as far east as Ohio, Indiana, and southern Michigan. On Isle Royale this climatic change resulted in the decline of spruce and an increase of pine, oak, maple, and yellow birch. The pollen record in bogs suggests that toward the end of this warm period hemlock, basswood, elm, walnut, and hickory also may have grown on the island, though none of these is present today. Spruce-fir forests probably survived only in cool, wet areas near the shores, in swamps, and on some north-facing slopes, while the deciduous hardwoods covered most of the uplands.

The spring peeper, which may have reached the island on driftwood, breeds in water but lives as an adult in shrubby vegetation.

Animal life probably changed in a similar way, with increase of the more southerly species and decrease of northerly ones. Reptiles and amphibians, being cold-blooded and therefore requiring fairly warm climates, quite possibly survived on the island for the first time. Some aquatic species, such as newts and painted turtles, may have been able to swim through the temperate water. Other turtles, frogs, snakes, and salamanders, as well as their eggs, may have been carried on or in driftwood to these shores. Most probably they came from the Ontario shore to the north and east, since the prevailing currents come from that direction.

Warmer water during this period no doubt also aided fish in crossing the big lake and becoming established in Isle Royale waters. Some larger species may have found a new home throughout the lake, while some smaller ones

accompanied "rafts" of flotsam to sheltered water around the island, and then traveled upstream to interior lakes. At the same time, the cold-water fishes such as whitefish and trout, which probably had become established in Isle Royale lakes during colder times, now could not tolerate the warmer inland waters and died off in all but the deepest lakes. Lake trout, for instance, now live only in Siskiwit Lake, while whitefish survive only in Desor and Siskiwit.



Monument Rock, a sea stack at an elevation of about 700 feet above sea level, is a remnant of the shoreline of ancient Lake Minong.

Gravel beaches have formed at some indentations in the rocky shoreline. >

About 5,000 B.P., near the end of the warm "pine period," the level of the three upper Great Lakes, now all at the same elevation, stabilized long enough to form another prominent shoreline. This gigantic body of water, known as Lake Nipissing, formed beach ridges, sea arches, and other features on Isle Royale at elevations now from 640 to 660 feet above sea level. (Lake Superior is about 600 feet above sea level.) During this stage a bar forming across a cove mouth created Lake Halloran, a sea arch was cut on Amygdaloid Island, and Suzy's Cave, facing Rock Harbor, was carved out by the waves. By this time, with lake levels only 40 to 60 feet higher than now, Isle Royale had nearly reached its present configuration. Siskiwit Lake had been cut off from the big lake by a low ridge, and most of the other inland lakes had also been formed. (In another 3,000 years or so, the present Great Lakes would be formed and Isle Royale would have emerged to its present extent.)

Isle Royale's biologic story since that time has been shaped by increasing coolness. Spruce-fir forests have spread to all but the highest, driest areas, tightening a noose of competition around the remaining stands of sugar maple, yellow birch, and pine. Some "southerly" animals probably have been eliminated. Whether this trend will continue into another ice age or will shift toward greater warmth, we can only guess.

What life inhabits the island at this particular point in its long-short history? Many species for which the climate is suitable either could not make the trip across or, once arrived, could not become established. Most of the plants and birds of the nearby Canadian mainland have succeeded on the island, but many other forms of life have not. Among the missing vertebrates are black bear, white-tailed deer, raccoon, striped skunk, porcupine, eastern cottontail, and a number of small rodents, as well as snapping turtle, spotted and red-backed salamanders, and leopard frog. The island's wildlife drama today has only a few principal mammal actors: wolf, moose, beaver, snowshoe hare, red squirrel and deer mouse; the few other mammals are uncommon, rare, or ecologically unimportant. Perhaps the small size of the mammal cast heightens our interest in it; certainly it focuses the action of the play.

Many processes of creation and destruction continue today as they have since rotten ice first melted off this piece of land. Ever so slowly, rock weathers and helps to form soil. Still responding to the removal of its tremendous burden of ice, the northern part of the Superior Basin rises a foot or more per century. Waves carve into the rock shores, make beaches, and build bars underwater across coves. Lichens and the plants that follow create forest on rock. Creeping mats of vegetation form "cataracts" over the eyes of lakes and eventually fill them. We witness on youthful Isle Royale the earth's primordial work.

< Minong Ridge, near McCargoe Cove, is the site of both prehistoric Indian copper diggings and a late 19th-century mining operation of the Minong Company.

Man Comes—And Goes

If you spend much time at Rock Harbor, chances are you will take a walk out toward Scoville Point on the Stoll Trail. About halfway to the point you will pass three small pits in the rock—a small sample of many pits excavated on Isle Royale by Indians, hundreds of years ago, in their mining of copper. Collectively, they represent man's first appearance on this young island.

In many ways, Indian use of Isle Royale was like most later human activity here: it was seasonal and exploitative, and finally it was abandoned. Unlike other animals, man has never been able to live long-term and harmoniously with this rigorous, remote land.

As we have seen, plants followed close after the retreat of glacial ice out of the Superior Basin, and animals followed the plants. Close upon the heels of animals came man, the hunter. By 6000 or 7000 B.C., possibly earlier, Indians had reached the north shore of the lake. We don't know when they first ventured the 15 or 20 miles to Isle Royale; but by about 2000 B.C.

they were mining copper on the island. (Wood from a pit near Lookout Louise has been radiocarbon-dated at 2160 B.C. plus-or-minus 130 years.) Using rounded beach cobbles, they hammered the rock away from the pinkish veins of pure copper. Perhaps, too, they used fire to heat the rock and make it more friable, though this is uncertain. Probably these early visitors came in small groups during the summer, worked a number of pits, and returned to the mainland for the winter. Quite possibly they burned off the vegetation, as white miners later did, to find the copper veins more easily. They used the malleable metal for spear points and other implements.

For about 1,000 years, Indians mined copper on Isle Royale, the Keweenaw Peninsula, and other areas around Lake Superior. Some of this material, presumably through trade, found its way to southern Manitoba, the St. Lawrence Valley and New York, and northern Illinois and Indiana; but the chief area of use was eastern Wisconsin.

Then, on Isle Royale, the archeological record goes blank until about 300 B.C. By this time, little mining was being done here, though some use of copper continued. Much copper must have remained in circulation, however, for it was during the period from 500 B.C. to 500 A.D. that the Hopewell Indians of southern Ohio, Indiana, and Illinois used Lake Superior copper to make numerous highly artistic ornaments. We know that Indians used Isle Royale rather extensively during these centuries, since their occupation sites have been found at Indian Point (at the mouth of McCargoe Cove), Chippewa Harbor, Merritt Lane, Washington Island, and other places. Bones uncovered at the Indian Point site indicated some of the contemporaneous animal life: caribou, moose, beaver, lynx, snowshoe hare, muskrat, loon, bald eagle, sturgeon, shorthead redhorse sucker, and turtle.

Judging from the number of sites found, the period from 800 to 1600 saw the peak of Indian activity on Isle Royale. After the arrival of Europeans in the Great Lakes area, Indian culture began to disintegrate and their numbers declined. By the 1840's, when white miners came to Isle Royale, the only Indian encampments were one at Sugar Mountain, where they tapped maples for the sap, and a seasonal fishing camp on Grace Island.

In their 4,000 to 5,000 year use of Isle Royale, Indians apparently left only small pits in the rock as lasting marks on the landscape and life of the island. If they burned the plant cover in their search for copper or eliminated beaver or other animals in fur-trade days, there is no evidence of this today. They seem to have left the forests full of game and the waters full of fish.

The same cannot be said quite so confidently for those who followed, though modern man's record has been better here than it has in most places. During the 19th and 20th centuries, people have come for fish, copper, lumber, and finally for that most fragile and elusive of natural resources—wilderness. Even that last quest has left its mark on the land.

In historic times, fishing has been the most enduring economic activity on Isle Royale. The many reefs and miles of shoreline, as well as great range of water depths and several types of bottom material, provide for the varying seasonal needs of lake trout, whitefish, and herring—the chief species sought. Sheltered harbors give fishermen bases from which to operate.

Commercial fishing began here before 1800, when the Northwest Fur Company took fish from the north side of the island to supply its stations at the western end of Lake Superior. In the late 1830's, the American Fur Company established seven fishing stations on Isle Royale. Their catches were good, but the economic depression of 1837-41 dried up their markets. Since that time, commercial fishing on Isle Royale has continued largely as an individual enterprise, and for the most part it has been successful. Nearly every sheltered cove has had its fish houses and log cabins, where fishermen and their families lived from spring until fall. Most returned to mainland towns in winter, but a few hardy souls lived here year-round. For various reasons, fishing declined through the present century. In 1972, only four commercial fishermen still operated on the island, partly as employees of the National Park Service, which strives to maintain some of this activity as an integral part of Isle Royale life.

Lake Superior, though productive, has not remained the rich source of fish it was when Europeans first settled here. In the 1880's, when fishing was booming on Isle Royale, a decline in whitefish catches was noticed. Whether

This 1890 photograph shows a fishing village in sheltered Chippewa Harbor. Visitors to the harbor today find that the forest has grown up around the village site. The decline of Great Lakes fishing in this century brought about the abandonment of a number of such settlements.

overfishing was the main problem is not known, but whitefish numbers have remained low to the present.

Man's activities were directly responsible for a more recent shock to the Lake Superior ecosystem: the building of the Welland Canal allowed sea lampreys to bypass Niagara Falls and enter all the upper Great Lakes. By 1952, these eel-like, parasitic animals had appeared in Lake Superior. They attacked primarily the lake trout, and within a few years had decimated its populations. Fishermen were forced to turn to the herring, a smaller and less profitable species. Eventually, use of chemical poisons in spawning streams brought the lamprey under control and the lake trout recovered to the point where a small take became permissible. But herring remained the chief support of the declining Lake Superior fishery.

The introduction of smelt into the Great Lakes about 1912 was deliberate, but this, too, may have had some adverse effects. Smelt proliferated and now, in spring, run up Lake Superior streams in enormous numbers. Fried smelt make a tasty dish, but, according to many fishermen, they eat large numbers of eggs and fry of other fish, including the larger commercial species. This belief and other aspects of smelt ecology still await scientific study.

Of all economic enterprises on Isle Royale, copper mining undoubtedly has had the greatest environmental effects. The chief impact came from the use of fire to remove the plant cover from the rocks. As any bushwhacker today discovers, the underbrush is thick in many places. Copper prospectors burned thousands of acres to aid them in their search. In the next chapter we will trace some of the extensive biological effects of such fires. Miners also cut wood for fuel, building material, and mine props, and made clearings for settlements.

Post-Indian mining occurred only in the 19th century, during three periods of activity. The first lasted from 1843 to 1855. Much exploration was carried out, but only small quantities of copper were obtained, under dangerous and uncomfortable conditions. Two of the more easily seen mines from this period are the Smithwick Mine, a small, fence-rimmed excavation on the Moose Trail near Rock Harbor Lodge, and the Siskiwit Mine, which is on

the north shore of Rock Harbor opposite Mott Island.

Interest revived between 1873 and 1881, when larger (but fewer) operations, benefitting from improved mining technology and better transportation, were carried out. The largest of these was the Minong Mine, near McCargoe Cove. Following the lead of the prehistoric miners, who had dug hundreds of small pits in Minong Ridge, workers of the Minong Company sank two shafts and blasted large quarries in the ridge. At its peak, production here required 150 men who, with their families, formed a substantial settlement. There was a blacksmith shop, a stamp mill, an ore dock, and railroads between mine, mill, and dock. Today the mine area looks like the scene of some ancient bombing raid. "Poor rock" piles lie huge and bare in the forest. Pits and quarries yawn eerily in the side of the ridge. Rusted, twisted tracks go nowhere on their grass-grown roadbeds. Nothing remains of the town. Its site is now occupied by a lovely open forest of aspen, its openness the only hint of man's former presence.

The other substantial operation of this period was the Island Mine, about two miles northwest of the head of Siskiwit Bay. A town was laid out on the bay shore, and this became the county seat of the newly established Isle Royale County (now a part of Keweenaw County). But fire, low copper prices, and poor deposits cut short the life of the mine. Nothing remains of this town, either; but the Island Mine Trail, which follows the old road to the mine, passes by the shafts and rock piles, half-screened by the surrounding forest.

Pete Edisen with a record catch—16 boxes of lake herring—in 1965.

The final quest for copper lasted from 1889 to 1893 and centered in the Windigo area. A town was built at the head of Washington Harbor and extensive diamond drilling was conducted to locate the metal,

On the shore of Wright Island an abandoned fisherman's home is a reminder of the days when Isle Royale's fishery thrived.

but the deposits proved too poor. The only production from these efforts was geological data, on which much geological understanding was subsequently based. Thus ended man's 4,000-year search for copper on Isle Royale.

The island's isolation and its shallow soil, which does not allow large stands of tall trees to develop, may have been the chief factors that saved it from intensive lumbering. Aside from the cutting done by miners, there were only two significant episodes of lumbering. In the 1890's a Duluth company cut white-cedar and pine along Washington Creek and floated the logs down to Washington Harbor, where they were held in by boom chains. This venture ended when a big storm caused Washington Creek to flood and break the log barrier, sending the harvest out into Lake Superior.

Fire ended the other operation. In the early 1930's, while land acquisition for the newly authorized park was underway, the Consolidated Paper Company was logging spruce and fir from its holdings at the head of Siskiwit Bay. In July 1936 a fire started near the lumber camp and eventually burned nearly a quarter of the island. Though 18,000 cords of pulpwood stacked near the bay were saved, much of the company's forest holding was left a charred wasteland.

While men sought, rather unsuccessfully, to exploit the island's natural resources commercially, a nonconsumptive form of exploitation—one that

would eventually assume dominance—was beginning. Since the 1860's a few tourists had been coming to Isle Royale to enjoy its fishing and its tranquil, remote, romantic wildness. During the early 1900's, with the rapid growth of midwestern cities and the introduction of lake excursion boats, tourism picked up. Resorts were built on Washington Island and at Windigo, Belle Isle, Tobin Harbor, and Rock Harbor. People acquired cottage sites, particularly on the islands and long peninsulas at the northeast end of the island.

The appreciation of cottagers and tourists for Isle Royale's peace-giving blend of woods and water eventually crystallized into a movement to make the island a park. At first a state park was visualized, but later sentiment favored a national park. In 1922, Representative James C. Cramton of Michigan made the proposal in Congress. After a long battle between proponents and opponents, Congress in 1931 passed a bill making Isle Royale a National Park project. Lands were gradually acquired and several Civilian Conservation Corps camps were set up to construct trails, fire towers, and the necessary buildings. Isle Royale National Park was formally established in 1940 and was officially dedicated in 1946. Then, as now, occasional foul weather complicated travel to the island. The Park Service director and assistant director were unable to fly from Houghton for the dedication ceremony; 1,000 others made it by some means.

Isle Royale's preservation as a park was the achievement of many people, but the man who first planted the idea in many minds was Albert Stoll, Jr., a Detroit newspaperman. After a visit to Isle Royale in 1920, he wrote a series of editorials, for the Detroit News, promoting park status for the island. The trail now memorializing him leads past the Indian pits mentioned at the beginning of this chapter to a plaque about Stoll at Scoville Point, thus touching on the first and also the most recent phases in man's long relationship with this island.

What did the people of the United States inherit from the prehistoric past through establishment of this park? Remarkably much, we can conclude. Man may have eliminated the lynx and the marten from the island by trapping, and he probably had diminished the fish populations around its shores.

He had introduced some non-native plants such as clover and had made clearings in the forest. But generally his activities had not disturbed the normal workings of nature. His fires, though concentrated in time and far-reaching in their effects, apparently had the same long-term results as the lightning fires that surely have burned this island since it first bore trees. For some decades he had not hunted the animals but had let predators, prey, and vegetation find their natural balance. He did introduce the Norway rat and white-tailed deer, but these did not survive long. In 1946, excluding a few buildings and trails, the island scene and its plant and animal components were probably nearly the same as they had been four centuries earlier, before Europeans arrived here and set eyes on the "floating" island.

Most of Isle Royale National Park is kept in a wild state, with a minimum of visitor developments such as this boardwalk through the white-cedar swamp on Rock Harbor Trail.

To be sure, however, some "natural" changes had occurred, particularly among the larger animals. Woodland caribou, probably residents of the island much of the time since early post-glacial days, disappeared about 1927. Moose, probably present at various times in the past but absent during the 19th century, reappeared early in the 20th. Coyotes were seen and heard through the first half of the 20th century, but disappeared about 1955. And wolves, which no doubt hunted moose and caribou here in distant centuries, were not regular residents during the 19th and early 20th centuries but became firmly established in the 1940's. Thus change has continued, with or without the presence of man, since the island was born.

As commercial fishing declines and cottage leases expire, old ways of life on Isle Royale fade away. But in some ways the pattern of human activity remains the same. Visitors come for a few days and return home. Park Service people and a few others come in spring and leave in the fall. No one stays permanently. For a week or a season the island attracts us, but in the end the wild forces beneath the beauty send us back across the water. Only for moose and beaver, wolf and raven, spruce and fir is Isle Royale a true home.

Fire, Wind, And The Changing Forests

Walking the middle section of the Greenstone Trail, one passes through dense young forests of birch and aspen. Here and there a dead pine stub rises above the living trees, and charred stumps twist upward among the white trunks. All these are the present signs of the most destructive event on Isle Royale in this century, and of nature's enormous powers of recuperation.

In the summer of 1936, Minnesota, Wisconsin, and Michigan lay in the grip of a deep drought. On Isle Royale, slash from logging operations in the Big Siskiwit River area covered the ground. On July 25, man or lightning started a fire near the logging camp at the head of Siskiwit Bay. The fire eventually burned a large area west of the camp, jumped northward and consumed forests all the way from Lake Desor to Moskey Basin. Not until mid-August, when a shift in wind and heavy rains helped the 1800 firefighters, was the fire put out. It left 27,000 acres a jumble of charred logs.

But the dense green forest now covering these slopes shows that nature can

cope with fire. Fire, in fact, is a part of nature, an element to which plant and animal species have become adapted. Other forces, too, attack the forests, and form a part of the total pattern of life. Wind blows trees down; insects devour leaves and tunnel through trunks; disease enters; animals browse saplings or cut trees. All these agents keep the forests in slow turmoil, in continual cycles and sub-cycles of destruction and re-creation.

Indeed, more than half of the forest on Isle Royale is in some stage of recovery from fire and other destructive forces—not yet, that is, in a mature stage in which certain tree species have attained long-term dominance. The process of succession toward that state is continuous; but disturbances, particularly the strong winds, work against the attainment of a mature, stable forest over the whole island. Instead, there is a patchwork of forest types, generally following the linear pattern of ridges and valleys but made more random by the chance effects of destructive forces.

The 1936 burn, seen from Greenstone Ridge, is undergoing a slow process of recovery.

On most of Isle Royale—that part most affected by the layer of cool, moist air over Lake Superior—the trend is toward a forest of white spruce and balsam fir. Sizable patches approaching this type, though containing much birch and aspen, occur near the shorelines. Forests of old aspen and paper birch in which spruce and fir have not yet become dominant occupy a larger area. On the central ridges in the southwestern part of the island, where soils are fairly deep and the climate is somewhat warmer, mature forests of sugar maple and yellow birch have stood for a long time, apparently little affected by fire. This type and spruce-fir represent the two "climax" forest types on Isle Royale. Most of the 1936 burn area

should progress toward these two kinds of forest. Other types on the island are swamp forests of black spruce, white cedar, and fir; and small areas of jack pine on some rocky, south-facing slopes and ridgetops. These forests may eventually join the dominant white spruce-fir forest, as swamp soils dry and spruce grows up in the shade of the pines.

When fire strikes hard, burning trees as well as ground cover, it sets back succession to an early stage. Where fire is particularly intense, it may consume all organic matter in the soil and, together with the erosion that often follows, strip the surface down to bare rock. But in most places some ash-covered soil is left. From this, grasses, fireweed, pearly everlasting, and other herbaceous plants soon sprout, speckling the blackened earth with green. These are followed by woody plants: thickets of hazelnut, seedlings of juneberry, pin cherry, and choke cherry. Paper birches, aspens, and mountain ashes, killed aboveground, resprout from stem and roots below ground, sending up several shoots in place of each single stem burned. In a few years an open grassy area, dotted with shrubs and small trees, has developed. Grasshoppers, flies, bees, chipping sparrows and song sparrows find such places to their liking.

These spruces and firs will eventually replace the birches under which they started.

Thimbleberry is a shade-tolerant plant of the forest floor.

As shrub clumps and tree sprouts grow over the fire-felled logs, making a dense tangle of greenery,

snowshoe hares take advantage of the combination of food and cover, and red foxes take advantage of the hares. Moose find a lot of browse in such places, and wolves find moose.

If conditions are right, the trees grow rapidly. Gradually the shrubs are shaded out, the logs rot, and lower tree branches die, reducing the amount of food that hares can reach and eliminating many of their hiding places. After 30 years or so, the trees may be too tall to supply food even for moose. At this stage, the forest is a monotonous, even-aged stand of close-packed young birches and aspens, with a few small spruces and an occasional fir underneath, the result of seeds blown or carried in from older forests. Here and there a white pine shoots up, perhaps one day to tower above all the other trees. The forest floor, now fairly well shaded, is likely to be covered with thimbleberry, large-leaved aster, bracken fern, or wild sarsaparilla, with perhaps a few bunchberries and bluebead-lilies underneath them. As might be expected from the lack of variety in habitats, animal life is rather scarce. One may see only an occasional red squirrel or moose, and a few birds such as red-eyed vireos, ovenbirds, and chickadees. But variety will grow with age.

This stage may be slow in developing, however, because of heavy browsing by moose. Aspens and birches in some of the 1936 burn area are still quite suppressed. Through all stages of growth, moose strongly affect the structure and composition of the forest.

On some burned areas, particularly dry slopes and ridgetops, spruce and jack pine, rather than birch and aspen, are the pioneer trees. In such places there may be little change in the tree species present as the stand grows older.

In a typical stand of young birches and aspens, competition among the trees for water, light, and minerals gradually thins the stand as the survivors grow taller. Spruces and firs, now germinating more abundantly, begin to create a dark layer beneath the birches and aspens. The firs, however, will be under continual pressure from moose browsing, and few will "escape" to become part of the overstory.

A hundred years or more after the fire, the spruces, along with some firs, may gain dominance over the deciduous trees. Gradually the aspens reach

the end of their life span. Where the conifers stand close together the aspens leave few offspring, for here the forest floor is too shady for survival of the seedlings. Paper birches, usually more numerous, survive longer as a forest component, but their seedlings and root sprouts have the same problem. Given enough time and lack of disturbance, most of the birch would disappear, too, and a dark forest of spruce and fir would develop. For a number of reasons (which were stated earlier and which we will examine later) this seldom happens on Isle Royale.

These maturing forests, with their mixture of conifers and broad-leaved trees, provide homes for much more wildlife than do the dense young stands. Red squirrels, attracted by the seeds and thick cover of conifers, become common. Warblers, thrushes, red-breasted nuthatches, winter wrens, white-throated sparrows, and many other birds occupy the variety of niches now available.

If the area is above the influence of the layer of cool moist air that lies over Lake Superior, it may change from a young paper birch-aspen stand into a sugar maple-yellow birch forest rather than spruce-fir. In this case, a dense crop of sugar maple seedlings develops under the birches and aspens, and the maples, with a sprinkling of yellow birches, eventually take over. In some areas, red maples, red oaks, and white pines may be important in the successional stages. In the mature maple-birch forest, which shelters a few conifers in moist places, squirrels and birds are also much more abundant than in the earlier stage of the forest, though this type seems to have less variety of wildlife than does spruce-fir forest.

The relative variety and abundance of life in the later stages of forest succession is due partly to the several layers within them. There is the canopy, high above the ground and struck with sunlight. There is an understory, composed mostly of young of the canopy trees. There are shade-loving shrubs and small plants near ground level. But the variety is due also to destructive forces, which create openings in the forest and thus provide additional habitats.

Besides fire—which burns small areas much more often than large ones—

< Snowshoe hares abound on old burns where shrubs and fallen trees make thick cover.

Feeding by the aspen leaf roller (caterpillar of the large aspen tortrix moth) caused heavy damage to aspen forests in the early 1970's.

wind, insects, larger animals, and disease contribute to the constant change in forest structure. Wind, aided by thinness of soils and trunk-weakening diseases, probably takes the lives of more trees than does any other agent. Over most of Isle Royale, the last glacier was stingy with its deposits, and there has not been enough time since then for deep soils to develop. The shallow root systems of spruce and fir, anchored in thin, often wet soil over rocks, provide poor resistance to strong winds. Particularly during fall storms or high winds in winter, when trees may be laden with ice or snow, trees fall by the hundreds. Balsam fir is frequently afflicted with heart rot and this adds to its susceptibility, often causing it to snap off in high wind. Blowdowns are thus a common sight on Isle Royale, creating barriers for the hiker, cover and food for animals, and many openings in the forest.

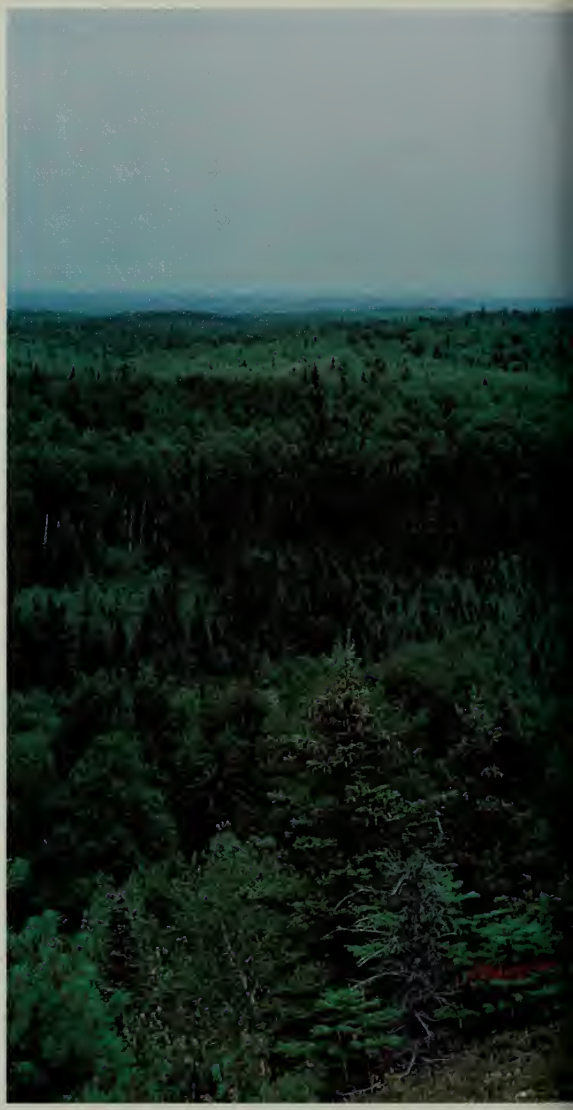
Insect outbreaks periodically add their effects to those of other agents of destruction. In the early part of the 20th century many tamaracks were killed by larch sawfly larvae, which eat the needles, and tamaracks are still scarce on the island. In the 1930's the spruce budworm destroyed many firs (which it prefers over spruce), in the same manner, but it is apparently doing little damage today. The chief insect scourge of the early 1970's was the large aspen tortrix (a close relative of the spruce budworm), which eats the leaves of aspen before making its cocoon inside a rolled-up leaf. Many acres of

aspens, particularly on the southwest end of the island, were defoliated; but most of the trees leafed out again. On a small scale every year, and on a large scale some years, insects contribute to the constant forest turnover.

Less dramatic but perhaps more important in the total effect on trees are diseases. Heart rot, mentioned earlier, is caused by fungi that enter the heartwood of trees. White pine blister rust, another fungus, kills white pines by destroying needles and girdling stems. Hundreds of other fungi, bacteria, and viruses attack trees, continually challenging their fitness to live and to dominate the area they shade.

The role played by vertebrates in forest change is especially evident on Isle Royale. Moose and beaver drastically affect the structure and composition of the forest, while other mammals, though by comparison unimportant agents, nevertheless have measurable effects.

In winter, moose feed extensively on the foliage and twigs of fir. The island's high population of moose has left browse lines on most stands of fir, denuding many of the branches



< In this view from Minong Ridge near Linklater Lake, spruces and firs form dark patches amid the lighter aspens and birches—a typical pattern on Isle Royale.

Two moose forage in the shallows of Washington Creek.

from the snowline to about eight feet above the ground. They often break the tops of small firs to reach the foliage there. This heavy browsing of fir has the net result of decreasing the fir component of the forest and increasing the proportion of spruce, which moose do not eat. Moose are also especially fond of aspen, mountain-ash, paper birch, pin cherry, mountain maple, and red maple; in some areas they keep saplings of these species perennially browsed back to shrub height. Earlier in this century, moose virtually removed the American yew, an evergreen shrub that once formed dense thickets on the island. Only on certain offshore islands, such as Raspberry and Passage, where moose seldom or never go, does yew continue to flourish. Elsewhere, since moose eat the more conspicuous individuals, only small specimens of yew can be found. In a later chapter we will further examine the moose-vegetation relationship on Isle Royale.

Beavers, of course, dramatically change the forest in the vicinity of their ponds, which on some parts of Isle Royale form a large part of the landscape. Trees are killed in the flooded area, and many aspens and birches within 150 feet or more of the pond are felled. The beavers thus maintain open areas in the forest, and to some extent encourage the growth of spruce and fir through the removal of aspen and birch. Intense suckering—sprouting of shoots from the base of a trunk—occurs when beavers cut aspens.

Snowshoe hares feed on many of the same plants that moose eat; but their comparative effect on vegetation is small. As with moose, they have the greatest impact on the forest in winter, when only woody stems, twigs, and bark are available to the hares. Since they can reach about two feet above the surface of the snow, they browse up to a height of four or five feet.

Insects, birds, and mammals also play a productive role in the forest. Insects aid in seed production by pollinating flowers. Birds and mammals disperse seeds, sometimes inadvertently, and aid in germination by burying some and softening the coats of others in their digestive tracts.

The forest, then, is an ever-changing mixture of plants, acted upon and influenced by all the forces of the environment, including the whole spectrum of animal life that dwells within it. While hiking on Isle Royale, particularly on trails that cut across the topographic grain, one sees a mosaic of forest types and stages: damp shoreline forests of fir, spruce, and birch dripping with beard moss; open, shrub-dotted stands of tall aspens and birches; dense, dark swamps of black spruce and white-cedar; sun-baked grassy ridgetops, slowly recovering from some long-ago fire. Each part of the forest is coming from somewhere and going somewhere. None of it is standing still.

One purpose of national parks is to preserve places where nature is allowed to operate as much as possible without the interference of man. On Isle Royale, this *laissez-faire* policy extends even to fire. Though human-caused fires are put out, lightning fires are allowed to burn unless they threaten some campground or other developed area. Most of these are very small and go out soon. (This does not mean that fires are not carefully watched, however. Fire flights and fire tower operators quickly spot and follow the course of all fires.) Similarly, insect outbreaks are not checked. Nature eventually does this herself, through the effects of weather, food shortage, and predation by other insects and birds. For instance, the population explosion of the large aspen tortrix in the early 1970's was inhibited, if not checked, by an army of birds, including red crossbills, blackbirds, many kinds of warblers, and even woodpeckers that awkwardly crept out on the twigs and picked caterpillars off the leaves.

On Isle Royale, as in all wild places, the forces of creation and destruction work in some ultimate balance. This equal struggle of life against death creates many different patterns of existence in the woods and waters of this lonely, harsh, beautiful island.

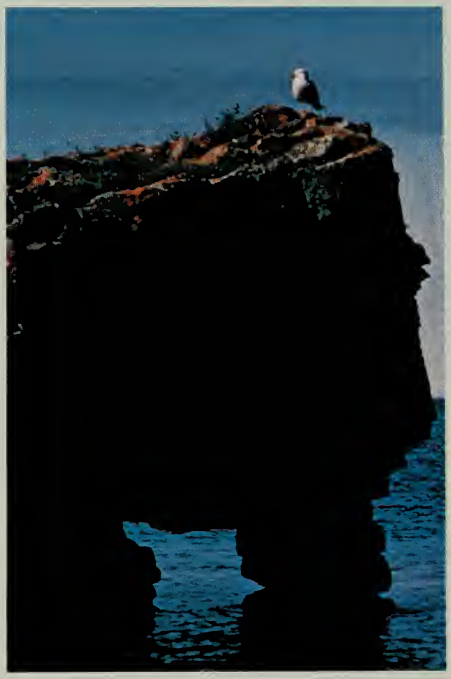
The Herring Gull: Shorelines

On his way down the shore of Rock Harbor, the hiker pauses to admire the scene. Under his feet, lichen-patterned rocks slope down to the lapping water. Down the trail, dark pointed conifers crowd the shore. And beyond the trees, Rock Harbor and its flanking string of islands stretch away to unknown places. Maybe before he leaves the island he will try for trout along this shore, and maybe he will get out to the lake side of those fringing islands to explore the wave-struck rocks. The possibilities of his adventure are endless. But right now he wants to get to Three Mile Camp to make his first dinner. He adjusts the new red pack on his back and continues down the trail.

High in the air above him, a female herring gull surveys the same scene. At the moment, only one aspect of it interests her—the food it might offer. She has two downy young in a nest on Burnt Island, and their demands are incessant. Her keen, cold yellow eyes catch a red spot moving through the trees; but the hiker is not eating. She glides down over the docks at Rock

Harbor Lodge. The black ducks are there, paddling along the shore, but no one is feeding them. She turns and flies across Rock Harbor toward Raspberry Island.

On the outer side of the island the gull lands on a big rock. All along this shore the gray basalt slopes down from the thick forest to the crashing waves. It is not a very productive place from a gull's point of view, but a surprising amount of life nevertheless exists here. Above reach of the waves and winter ice, lichens, mosses, and crevice plants —three-toothed cinquefoil, harebell, and others—add color to the scene, while closer to the forest edge trailing juniper, ninebark, willows, and other shrubs form a denser cover on the rocks. Under and through the plants, a few ants and spiders search for food, and snails make their slow way. It is mid-June, and a tiny chorus frog, hidden in a mossy rain pool, is still calling. New tadpoles lie on the silty bottoms of other pools in the rock.



A gull rests on a natural bridge on the rugged shore of Raspberry Island.

The gull watches disinterestedly as two myrtle warblers fly from the forest down to the water's edge and begin investigating a stranded log. But when another gull drops from the air toward something floating on the water, she takes off screaming and flies at the other bird, driving it away. She settles on the water and begins pecking rapidly at the prize—a dead sucker. Now other gulls arrive to dispute her ownership. Swooping, crying, splashing, they rip at the fish until one retains it long enough to swallow it. The gulls then fly

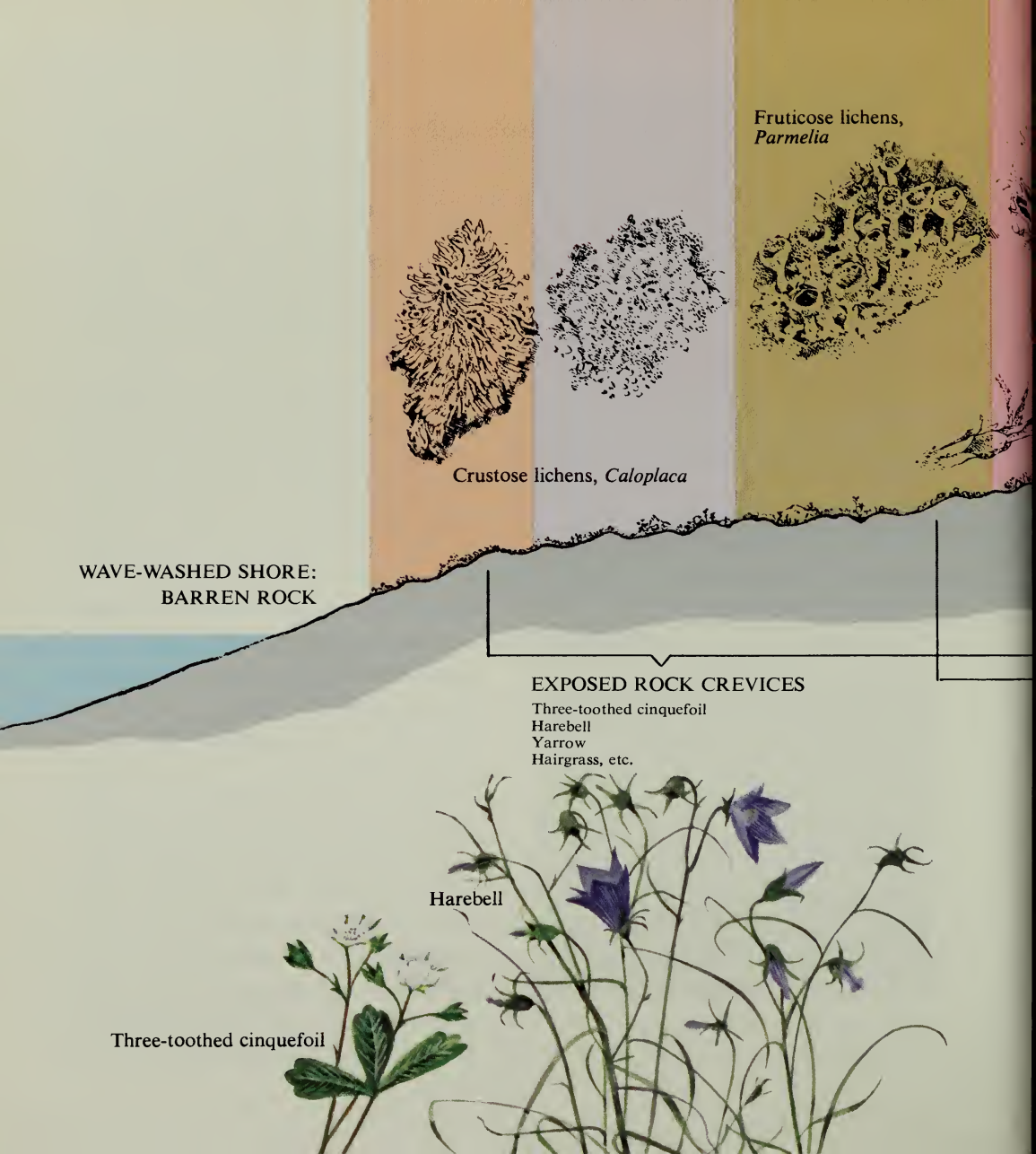
their separate ways, except for the female, who remains on the water to smooth her ruffled feathers.

Nearby a loon hunts where the gull can't go—beneath the water. Here the shore rocks angle down, full of crevices and indentations where lake chubs, sticklebacks, and other small fish hide. The loon passes these and dives deeper, down to the quieter haunts of lake trout, burbot, cisco, and white sucker. It spots a young burbot, and using its wings for extra speed, churns after the fish. Successful, the loon swallows the fish and returns to the surface for air. When the bird tires, it will abandon the pursuit of fish and hunt snails in the shallower water.

Meanwhile the gull has started a patrol flight down the shore. Briefly it circles over a beaver lodge on the inner side of Smithwick Island, built where it is sheltered from waves. Beavers on these islands are safe from wolves in summer, but their supply of aspen and birch is running low. More and more they are being forced to cut alder, mountain maple, and other less-preferred food. The gull sees no sign of life around the lodge—no frogs, no sunning snakes, no young birds—and flies on.

Gliding over Lorelei Lane, the narrow channel that splits the islands into two parallel strings, she sees families of goldeneyes and mergansers swimming near the shores. Each group of downy hatchling ducks is led by its mother, who dives for fish from time to time but never leaves her young for long. Suddenly the gull notices a little red-breasted merganser that has lagged behind. She swoops quickly, but somehow the mother merganser gets there first, and rising almost out of the water, wards off the gull with beak and wings. The gull continues southwestward down the island chain.

Goldeneyes nest in tree cavities and take their young to nearby waters to feed.


Fruticose lichens,
Parmelia
Crustose lichens, *Caloplaca*
WAVE-WASHED SHORE:
BARREN ROCK
EXPOSED ROCK CREVICES
Three-toothed cinquefoil
Harebell
Yarrow
Hairgrass, etc.
Harebell
Three-toothed cinquefoil

Reindeer moss

White-cedar

Juniper

EARLY CLIMAX TREES

Balsam fir
White spruce
Paper birch

MORE SHELTERED CREVICES

Butterwort
Alpine buckwheat
Grass of Parnassus, etc.

ADVANCED CREVICE PLANTS

Blueberry
Bearberry
Climax species, etc.

Bearberry

Butterwort

Paper birch

Balsam fir

Large-leaved aster

Canada dogwood

At Mott Island she lands on a little gravel beach, one of many that occur on indentations of the shoreline between rocky stretches. High up the beach, near the fringing alders and fir forest, driftwood and other debris lies in tangled rows, cast up by storms. The gull walks deliberately along these rows, now and then turning over sticks and snatching spiders, beetles, and other small things hiding there. Once she tries for a butterfly that has been attracted to the rotting organic mass. But pickings are thin here too. She takes off and wings strongly toward a place which, in the past, has been rewarding.

Even over the old Rock Harbor Lighthouse, now tilting slightly in disuse, the gull knows food is at hand. She has spotted Pete Edisen, a commercial fisherman here since 1916, out on his dock cleaning fish. Just for fun this time, he has been trolling in Middle Islands Passage and has caught four hefty lake trout. The gull is accustomed to Pete and lands without hesitation on the post at the end of the dock. As he has done for decades, Pete looks up with a smile and tosses the entrails toward the big white bird. Leaving the heads for later, she gulps the entrails whole and with a quiet cry heads toward Burnt Island, near the lighthouse, where her two offspring wait in a shallow nest on the rocks.

Burnt Island, one of many around Isle Royale used by gulls for nesting, is a tall, flat-topped, half-acre rock crowned with a miniature forest of fir, spruce, white-cedar, birch, and aspen. It is the home of song sparrows, foraging beavers, and some 75 pairs of herring gulls. Most of the gulls build their simple, grass- and moss-lined nests in the open at the edge of the trees. Here, beside a low juniper bush, the female and her mate have hatched and raised two light-grey balls of down that now rise on their black legs and with loud peeps greet their mother. Directed by some ancient instinct, they peck at the red spot on her bill until she opens it and regurgitates all she has found this afternoon.

If the food keeps coming day after day, if the weather is not too severe, if they are not killed by a hawk, fox, or another gull, and if they survive three or four winters of southward migration, they may reach adulthood and raise

young of their own. But the odds are not good. Perhaps in two or three years the parents will raise four or five young, and perhaps two of these will live to replace their parents. The environment of which the gulls are a part cannot support all that hatch. Nor can it support all the young ducks or all the insects. The gulls are one of many agents that keep these within bounds. As predator, competitor, scavenger, and prey, the herring gull is an important strand in the Isle Royale web of life.

Her young satisfied for now, the female gull flies northward through other circling gulls, on another search.

For the herring gull, Isle Royale's shore zone means food and shelter—in short, home. For man, it means beauty, interest, adventure, a place to fish. This meeting place of land and water has a mysterious attraction for us perhaps greater than that of any other island environment. Let's look at it now, as it gradually changes around the island's rim. We will explore the shore not in gull fashion, but as a boatman would.

Southwest from Rock Harbor, the basalt humps up steeply from the water, with few gravel beaches for the small boater to land on. Several miles along, a narrow, cliff-walled gap leads into the quiet recesses of Chippewa Harbor.

About two or three miles east of Malone Bay there is a fundamental change in the shoreline, as the surface rock becomes sandstone and conglomerate. Less resistant to the waves than basalt, these rocks make low shores where forest comes down almost to the water. These reddish rocks form the shoreline all the way around to Grace Harbor, at the southwest end of the island.

Malone Bay and Siskiwit Bay, a big scoop out of the island's southern shore, form a distinctive watery environment. Islands, reefs, shallows, deep water, relatively sheltered conditions, and collected nutrients make this area

attractive to fish, which in turn attract ducks, loons, herons, gulls, a few otters, and fishermen. This was one of the chief centers of commercial fishing on Isle Royale, and today it is visited by many sport fishermen in search mainly of lake trout. Some of the islands that string out northeastward from Point Houghton, forming the outer edge of the bay, have been used by gulls for years as a nesting ground. Isle Royale Lighthouse stands on Menagerie Island, at the end of the string, to warn ships.

At the head of Siskiwit Bay are the longest of Isle Royale's rare sand beaches. Made from fragments and grains of red sandstone and conglomerate, these beaches have a reddish color. Moose often follow these shores, leaving deep cloven hoof prints. Occasionally their tracks are paralleled by those of wolves, which use the beach as a regular pathway because of its convenience. In winter, when ice covers the bay, wolf packs often cut straight across the bay from Point Houghton.

From Siskiwit Bay around to Washington Harbor, there is little

The shorelines of Isle Royale range from treelined gravel beaches to bare rock, as illustrated in these scenes from Malone Bay, Siskiwit Bay, Scoville Point, Mott Island, and the north shore.

shelter for the boatman. The prevailing west or southwest wind drives the waves unopposed into the shore. Washington Harbor, with its deep recesses, islands, and nutrient-feeding Washington Creek, forms another "oasis" of shelter and life at the southwest end of the island. Like Siskiwit Bay, it is another gathering spot for fish, fishermen, ducks, moose, and other creatures. Washington Island, at the mouth of the harbor, has long been a base for commercial fishermen. At the head of Washington Harbor, Washington Creek brings down organic matter and silt, forming a rich, shallow delta where it enters the harbor. Underwater plants grow thickly on this delta, attracting fish and thus ducks, grebes, loons, and herons. The aquatic plants also attract moose, which come at all times of the day and night to feed on them. Sometimes submerging completely, the big bulls come up with water cascading off their wide backs, chewing contentedly on the succulent "salad." In spring rainbow trout and in fall brook trout run up the stream to spawn. A campground and ranger station here at Windigo are fortunately situated for enjoying this focal point of animal life.

Stretching from Washington Harbor to Blake Point, Isle Royale's north shore evokes feelings of adventure, respect, and sometimes fear. When strong northerly winds are blowing, the boatman has few places of refuge along much of this straight, cliff-faced shore. Here the waves are most awesome,

beating up against the rock with enough force over the centuries to carve sea caves and arches. Even gulls seem scarcer here, though gulls, herons, and cormorants nest on small offshore islands.

One feels like pausing when he reaches the security of McCargoe Cove, a long, straight cleft angling into the island, created by down-thrusting of the rocks along a fault. At the head of this cove, Chickenbone Creek has formed another delta. The stream now winds through dense alders growing on the stream's deposits. This, too, is a rich spot for animals. Here I have watched beavers, a muskrat, ducks, loons, and moose, and once saw a pigeon hawk trying to catch blackbirds roosting in the alders.

Continuing on our tour we reach the many-fingered northeastern end of Isle Royale, a seemingly endless alternation of long peninsulas and deep, island-dotted coves. Along these sheltered coves, trees grow nearly to the shore. At their heads, mussels abound in the quiet shallow water. This is the land-and-water scene that particularly attracted tourists and cottagers in pre-park days and today is the summer home of most of the remaining cottage leaseholders. It is prime canoe country where the portages are short and the possibilities for exploration are long. Several boaters' campgrounds provide good bases from which to enjoy this watery maze.

At Blake Point, the northeastern tip of the island, rough water often

Storm waves batter an islet near the north end of Isle Royale.

makes trouble for boaters. The water between Blake Point and Passage Island, in fact, is considered some of the worst in Lake Superior. Currents are strong and tricky here, and wind compounds the difficulty. The steep, rocky shore offers no shelter. Once around Blake Point, however, we enter Merritt Lane and then Rock Harbor, places of comparative safety.

Such a trip around Isle Royale engenders deep respect for the great lake as well as intimate acquaintance with the herring gull's world.

The Red Squirrel: Spruce-Fir Forest

Bird song and the gray light of dawn wake the red squirrel, curled in his grass-lined, leafy nest in an old woodpecker hole. He climbs out, sits on a branch of the dead birch that is his current home, and surveys his domain.

The acre he claims lies on top of a low ridge along the Moose Trail, about one-half mile east of Rock Harbor Lodge. An open, parklike forest of spruce, fir, birch, and a few aspens covers the ridge. Underneath, sapling firs outnumber the young spruces, but nearly all of the firs have been heavily browsed by moose, leaving the upper stems bare of foliage. Large-leaved aster, thimbleberry—with its big, maplelike leaves—wild sarsaparilla, white-flowered Canada dogwood, scattered bluebead lilies, and clumps of low juniper bushes cover most of the ground, but not thickly. Moss grows on rotting logs and stumps. On the north side of the ridge, where the underlying rock tilts steeply down to the shore of Tobin Harbor, moss, other ground plants, and young conifers are thicker, encouraged by the greater moisture. Here

old stumps of aspen, cut by beavers years ago, are beginning to rot. On the south side, where the rock slopes gently but faces the sun, the ground cover is scarcer, and includes some reindeer lichens on the rock and patches of bracken fern. At the foot of the slope lies a swamp, draining slowly between this little rise and the next. Here tall spruces cast shade on the grasses, ferns, horsetails, and broad-leaved skunk cabbage that cover the wet ground.

The red squirrel, which feeds on the seeds of conifers, is found in coniferous forests across North America from Nova Scotia to Alaska.

It is the third week in June. All the summer birds are back and are insistently proclaiming their territories. To the squirrel's ears come the ringing song of an oven-bird, the sweet loud whistle of a white-throated sparrow, the flutelike rising swirl of a Swainson's thrush. Nashville, magnolia, myrtle, blackburnian, and black-throated green warblers add their small but distinctive songs to the early-morning chorus. Down in the swamp, a winter wren unwinds its tinkling medley, and a little yellow-bellied flycatcher quietly whistles, "pur-wee." Intermittently, spring peepers peep.

None of these sounds is important to the squirrel, though they indicate the general locations of nests he might rob. But then a long, chattering "tcher-r-r-r" from down in the swamp electrifies his nerves. "Tcher-r-r-r!" he answers, vibrating with excitement and twitching his tail. It is another squirrel, one of two that occasionally wander up the slope into his terri-

tory. He calls again, angrily. Hearing no answer, he starts down the tree to begin the morning's foraging.

Many plants in the forest have something to offer him at one time or another, but now in early summer he is concentrating on the tender buds at the tips of spruce twigs. Stopping briefly on a log to nibble a bracket fungus, he then leaps up onto the trunk of a large spruce and scampers to its top, hardly pausing. For a half hour he carefully examines each branch, crawling out each one until it threatens to drop him. Then, surfeited with buds, he races down the trunk and out a limb, and winds through a succession of tree tops until he is above the top of the north slope. A crunching sound has roused his curiosity, and investigate he must. Below, half hidden in the foliage, a cow moose is stripping the leaves from young birches and noisily chewing them. Behind her, two small, light-brown calves nibble tentatively at ground plants. With the moose population high, most cows have borne only one calf, but these two seem to be thriving. For a week

The garter snake (shown here) and the red-bellied snake (not shown) are the only two species of snakes that have become established on Isle Royale. Garter snakes are found in many habitats, including wetlands; the secretive red-bellied snake frequents open woods and sphagnum bogs.

Canada dogwood, a tiny plant related to dogwood trees, grows on the floor of the coniferous forest. >

now the calves have followed their mother up and down Scoville Point, sometimes swimming across short stretches of water but seldom leaving the peninsula. Chances are that they will escape wolves this summer, because the pack on the island's northeast end seldom comes near the lodge area during the busy season. Two young bulls, and occasionally a yearling cow, wander through the squirrel's territory from time to time. He chatters at the trio below him, but they pay no attention.

Getting no response here, he works his way through trees and along the ground to a little grove where an aspen stands. Climbing the trunk he reaches a hole just as a downy woodpecker pops into it to feed four noisy young. The squirrel scurries around the hole excitedly, then loses interest and descends to investigate the ground.

Restlessly he bounds along the forest floor, through plants, along logs, then pauses, investigates under an old stump, emerges and continues. He knows every foot of his acre—what food it offers, what hiding places for himself and his seed stores, what possible nesting places. He also knows its dangers. A few woodpecker feathers lie scattered near the trail where some hawk or owl has feasted; it might as well have been squirrel fur. An old thigh bone of a hare under a juniper bush wakes an image of a red fox kill he witnessed here the past winter. The fox is a frequent visitor, forcing the squirrel to be ready always to dash for a tree or tunnel. Mink and weasel are occasional threats, but the marten, scourge of red squirrels through much of the north woods, no longer lives on the island. The deer mouse whose territory overlaps the squirrel's is a night animal, subject to attack by weasel, mink, fox, and especially owl. With alertness and luck, the squirrel may live two or three years. The mouse will do well to see another spring.

The squirrel pauses on a log to rest. Near him a bumblebee sprawls on the white bloom of a Canada dogwood. The late morning sun sparkles on the transparent wings of a hovering dragonfly, before it dives at a mosquito dancing in the air. There is an endless supply of mosquitoes; but there are also many birds that catch dragonflies. The dragonfly's chances for lasting the season are much less than those of squirrel or even mouse.

Feeling a certain lassitude in the warm sun, the squirrel climbs up a favorite spruce tree and stretches out on a limb where he can soak up the sun's rays. On the trail beneath him a little red-bellied snake also lies stretched, taking the sun. Like regular second hands of some giant clock, herring gulls fly over on their patrols of Tobin and Rock Harbor, drawing shadows through the dappled forest. Less often, ravens in ones and twos skim the tree tops, croaking as they pass. So familiar are these birds, the squirrel pays no attention. Suddenly a shape comes gliding *under* the tree tops. The squirrel tenses for flight, but the broad-winged hawk sails past him and lands on a branch over a small grassy pool. For several minutes it sits hunched and still. Then suddenly it drops toward a green frog at the edge of the pool. But at the last moment the frog dives; it will not today feed hatchling hawks a mile or two away on Tallman Island.

Some time later, after the hawk has left, the squirrel resumes his rounds. It is an uneventful afternoon, except for a short chase when he surprises one of the swamp squirrels raiding a food cache. The sun drops toward the ridge behind Tobin Harbor. Sitting beside the Moose Trail, the squirrel feels vibrations. A human family comes by. He runs up a small tree and chatters at them. They stop to look, then walk on. As the sun touches the top of the ridge behind Tobin Harbor, the squirrel starts toward his nest in the dead birch. He has successfully completed another day.

This particular squirrel's patch of forest, though unique like every other patch, has many elements found throughout Isle Royale's spruce-fir stands. The variations in these stands consist mostly in the proportions of the plants and animals common to all of them. The abundance of the constituent plants and animals in turn is determined by the moisture, soil, and sunlight, and by the history of the immediate area—recentness of fire, wind damage, intensity of moose browsing, and other things. All of

these factors are strongly influenced by the stand's topography and its location with respect to the Lake Superior shoreline.

Forests near the shore are the moistest and also most subject to wind damage and moose browsing. The cold waters of Lake Superior cool the adjacent layer of air and contribute moisture to it. This cool, moisture-laden air inhibits evaporation in the shoreline forests, thus allowing most of the moisture in the soil to remain there to be used by plants. A plus factor for tree growth, this is counterbalanced by the effect of wind, which can sweep across the wide expanses of the lake and hit the shore full force, toppling many trees. Shoreline forests also receive the heaviest winter browsing by moose, because these animals find here the greatest quantity of fir, a favorite winter food, and, because of the roof effect of close-packed conifers, somewhat lessened snow depths.

The spruce-fir forest grows to the water's edge on Inner Hill Island.

The result near shorelines is a damp forest of small trees with a high proportion of birch, which often springs up in wind-created openings; a high proportion of fir, which would be more numerous without moose; scattered white spruce trees, usually, because of greater resistance to windthrow, taller than the firs; a sprinkling of mountain-ash and white-cedar; and a generally thick, diverse cover of ground plants and shrubs. Old man's beard, a lichen resembling Spanish moss and dependent on high moisture, festoons the trees. Mott and Raspberry Islands have good examples of shoreline forest, though they do not suffer much moose browsing.

Inland and higher up, as the lake influence diminishes, temperatures become higher, thus increasing evaporation. Wind is reduced by the buffering

effect of ridges and by the intervening expanse of the forest itself. Old man's beard disappears. In sheltered valleys, trees can grow fairly tall.

One of the most noticeable changes inland is the increase of spruce and decrease of fir. This happens, apparently, because of differences at the surface of the soil. Near the shores decomposition of organic matter is slow on the cool ground. The litter of twigs, needles, and dead plants may become several inches thick. This layer of litter, filled with air spaces, tends to dry out fast after a rain, thus making a poor bed for tree seeds to germinate and grow on. But the roots of fir seedlings grow faster than do those of spruce, and thus are able to reach soil moisture sooner. In the shore zone, more firs survive to become trees. And fir is also more tolerant of shade. Inland, warmer temperatures speed up decomposition, reducing the depth of the litter layer. Also, the drier soil supports fewer trees, which shed less material onto the forest floor. The relative dryness also makes for more frequent and intense fire, which often produces open areas with mineral soil. Spruce is better able than fir to germinate and grow under these conditions and thus is more abundant inland.

The spruce on the left is unbrowsed; the firs on the right have been heavily browsed.

The spruce-fir situation illustrates one aspect of the intense competition between plants on the forest floor. In many places, the growth is so thick that tree seedlings of all species can get started only on rotten logs, stumps, or mossy rocks.

The ground cover in spruce-fir forests varies greatly, depending mainly on the amount of moisture and sunlight present. Where conifers stand close together, shutting out the sun, the forest floor is nearly bare of plants. Where

the canopy is more open, the ground is likely to be covered with mosses, club-mosses, ferns, and a wide variety of herbaceous plants, such as Canada dogwood, wild sarsaparilla, large-leaved aster, star flower, twin flower, wild lily-of-the-valley, blue-bead lily, and fringed polygala. Orchids, though less common, are frequently found; calypso orchid, one-leaf rein orchid, and spotted coralroot are among those forest species seen most often. In northern coniferous forests such as those on Isle Royale, many of the ground plants are evergreen—an adaptation to the short growing season. The wildflowers bloom abundantly through July, unlike those in the deciduous forest farther south, where the majority of flowers blossom in spring before unfurling tree leaves shut off most of the sunlight.

The spruce-fir climax forest on the Mount Franklin Trail looked like this in 1964. >

Twinflower grows in the spruce-fir forest along the Mount Franklin Trail.

The common shrubs include squashberry, red-berried elder, and bush honeysuckle. Where the forest is particularly open and contains much birch and aspen, thimbleberry abounds. This big-leaved plant with the red, raspberry-like fruits has an odd distribution. It occurs around the northern Great Lakes and from the Rocky Mountains northward and westward. Devil's-club, a spiny shrub restricted on Isle Royale to Blake Point, a few islands at Rock Harbor, and Passage Island, has an even more disjunct distribution. It occurs in a few places around Lake Superior, but its principal range is in the Pacific Northwest. The favored explanation for the split distribution of these

two species is that in early post-glacial times, when a cool, wet climate stretched all the way across the continent, they had a continuous distribution; when a warmer, drier climate expanded the central grasslands, the area where these plants could grow was cut in two. Climatic change is often a suspected factor when a plant or animal has such an odd range.

One's walks through these forests of spruce, fir, aspen, and birch are enlivened by encounters with animals. We meet the red squirrel most often; in fact, it seems to be everywhere. Squirrel populations on Isle Royale are higher than on the mainland, although one litter a year, averaging three young, is the rule (compared with two litters averaging more young in other areas). The lack of an efficient predator on squirrels, such as the marten, may be an important reason why Isle Royale's populations are so high. Red squirrels prefer mature forests where conifers abound, though their numbers are also high in sugar maple forests. Conifer seeds and fungi are their staple foods, but they also eat many other things, including seeds, flowers, fruits, and roots of various plants, as well as insects and carrion. Amazingly fewer young are born in poor cone years, though development of the cones occurs after the breeding season. Apparently, the females can detect early signs of cone production and in poor years avoid or inhibit conception.

The deer mouse is found in almost every state and in all the provinces of Canada.

Early or late in the day you may surprise a snowshoe hare nibbling some plant beside the trail. These animals occur where there is thick cover, such as low-spreading conifer boughs, windfalls, or dense shrubs. The population fluctuations of snowshoe hares are famous, though not well understood. Farther north the cyclic swings are enormous; on Isle Royale these are damped

but still quite noticeable. The cycles last about 10 years. Recent peaks on Isle Royale occurred in 1953 and 1963.

The deer mouse is the only small rodent on Isle Royale. Of the half dozen or so species of small rodents occurring on the nearby Canadian mainland, this is the only one that has bridged the water gap. Why this and no others is a mystery. Deer mice live throughout the island now but seem to be most abundant in coniferous forests. Individual deer mice, like squirrels, maintain territories. These range from about one-half to one acre in size. The resulting density of deer mice is thus quite low in comparison with that of some other small rodents that occur elsewhere.

The red fox preys on squirrel, hare, and mouse, but hares are its mainstay. So closely is the fox tied to this food source that its numbers fluctuate with those of the hare. Squirrels and mice are relatively unimportant fox food here, since the energy gained from them seldom justifies the energy required to catch them. Occasionally muskrats are caught, but these are too scarce on Isle Royale to provide much food. Birds, too, figure in the diet in a small way, as do frogs, snakes, fish, and insects. Isle Royale's foxes turn their main attention from hares only in late summer, when they gorge on fruits, particularly the dark blue berries of wild sarsaparilla. In winter, they supplement their hare diet with moose meat scavenged at wolf kills. Your chances of seeing foxes are good, since many of them have become accustomed to people at developed areas, and some have become panhandlers and camp robbers.

Like fox, hare, squirrel, and mouse, moose are found over virtually all of Isle Royale. Being dependent on moose, wolves, too, course the whole island. You are quite likely to meet moose, especially around lakes and ponds; but wolves are the island's needle in a haystack. With luck you may hear them howling, and with greater luck catch a glimpse, but for most people they are simply an unseen presence in the forest, adding to it a special dimension of wildness.

In a later chapter we shall look more closely at the lives of moose and wolves. Meanwhile, let's see what is happening in other land and water environments of Isle Royale.

The Black-throated Blue Warbler: Maple-Birch Forest

Nervously the warbler works its way toward the tip of the branch, now peering under a leaf for insects, now cocking its head to look skyward for hawks. In a world of green and gray and brown, it is easy to spot. Pale blue-gray mantles its head and back; a band of black runs from its face to its flank; its breast and belly and the spot at the bend of each wing are pure white. To a hawk, it would be a small but conspicuous morsel.

The green, shady world of this particular black-throated blue warbler is a small piece of the forests of sugar maple and yellow birch that blanket Isle Royale's southwestern highlands. The warbler lives at one end of a rise in the undulating crest of Greenstone Ridge, about three miles from Windigo. The trees atop this steep-sided, elongate, 5-acre knoll are mostly sugar maples, with some yellow birches and miniature groves of white-cedar, while on the relatively level, partly wet ground at its base there are more yellow birches and some firs among the maples. It is a highly structured world: dense

canopy above; next an open layer with lots of flying room; below that a layer of foliage ten to twenty feet above the ground formed by a multitude of sugar maple saplings; another open, nearly shrubless layer beneath that; and on the leaf-covered ground few plants but the tiny seedlings of sugar maple.

The warbler shares this shady knoll with two more mated blackthroated blue warblers, and with several other species of birds. There are pairs of blue jays, Swainson's thrushes, hairy and downy woodpeckers, black-capped chickadees, black and white warblers, and broad-winged hawks. The red-eyed vireo, black-throated green warbler, and oven-bird are each represented by three pairs. Living amongst the birds are three red squirrels. Each species uses the hill's resources in a different way, gleaning different kinds of food from it or searching only certain parts of it. The squirrels, for instance, hunt mostly seeds and buds, the thrushes and oven-birds work the ground for insects, the woodpeckers drill tree trunks for the larvae within, the red-eyed vireos search the sapling foliage and the canopy for insects, and the broad-winged hawks hunt everywhere—for squirrels, birds, and, especially in the wet places around the knoll, for frogs and snakes.

The creatures of each species, except the hawks, claim only a part of the knoll, a piece big enough to provide food for themselves and their young. This territory they defend against others of their kind, which otherwise would compete with them for food. For the hawks, however, the knoll is only a small part of their territory, which extends over two or three square miles.

The black-throated blue warbler rarely sees vertebrate animals other than these. Occasionally a moose wanders through, browsing on young sugar maples as it goes. Hares that headquarter in the swampy woods nearby sometimes venture to the foot of the slope, and once in a while a red fox passes by. The warbler has never seen the two deer mice which some nights scamper up the leafy slopes, or the toads that chance by after the spring breeding season.

The warbler pauses in its hunt for insects to advertise its presence. "Zoo, zoo, zreeeee," it buzzes. An answering call comes from the male black-throated blue at the other end of the rise. At intervals it repeats the song,

but it never comes closer. This is correct and satisfactory. The first warbler drops down to a young maple and then to the ground. It picks insects from a rotting log lying next to the bleached, half-buried bones of a cow moose killed here by wolves three winters before. The warbler cocks its head to watch the broad-winged hawk on its nest, thirty feet up in the fork of a yellow birch. The hawk is incubating eggs and poses no immediate threat.

With a beakful of insects the warbler flies to another log, beside which, in a low fork of a small maple, there is a neat little bark-adorned nest. Inside, the brownish female broods four tiny, naked young birds. Their faint "cheeps" are temporarily stilled as their father thrusts insects down their gaping throats. Then he flies up, up into the green vault arching above his world.

Walking southwest on the Greenstone Trail, one enters the maple-birch forest near the top of Mount Desor. After the long open ridges and young birch forests, it is like going into a tunnel. The sun and the views are screened off. One is forced to look at things close at hand, or to retreat to one's thoughts. On a hot day, the forest is a cool relief. On any day, it is an interesting change. Twelve miles down the trail, one finally emerges into daylight at Windigo.

Maple-birch forest also covers much of Red Oak Ridge southwestward from Siskiwit Lake, and some of Feldtmann Ridge. In future years it will probably reclaim several miles of Greenstone Ridge northeast from Mount Desor. This stretch, part of the 1936 burn area, is now covered with young birch and aspen, but underneath one sees thousands of small sugar maples awaiting their chance.

In general, the maple-birch forest occupies the warmest, driest parts of Isle Royale; this means the highlands farthest above the cooling influence of Lake Superior. But within the total area of the forest are many variations in

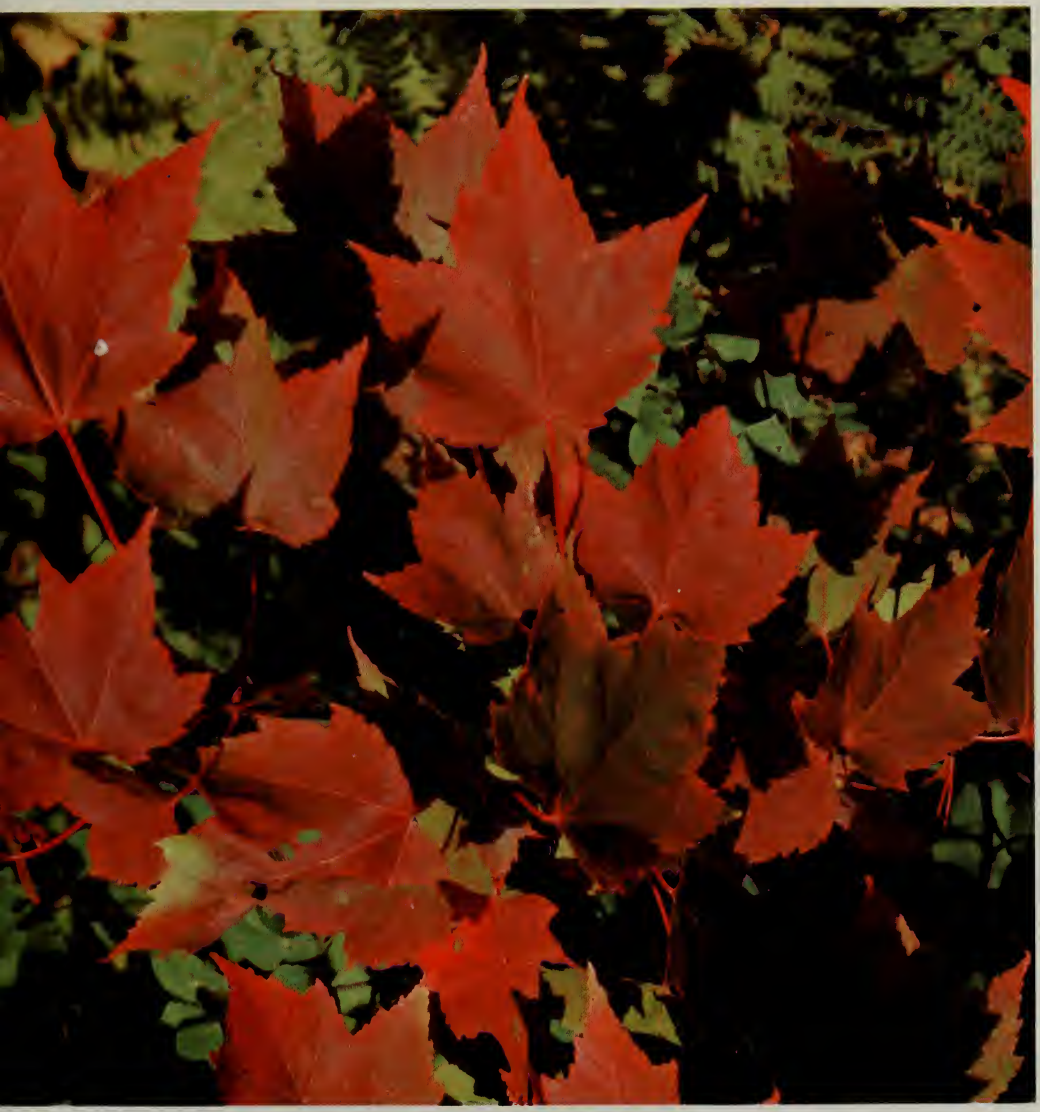
environment, which in turn produce variations in the forest.

Of the several tree species making up this forest type, each has its specific requirements. Sugar maple, the generally dominant species, occupies the warmest, driest areas, which also have fairly deep, well-drained soils. Altitude and southerly slopes provide the first conditions, glacial deposits the second. The tops of Mount Desor and Sugar Mountain have nearly pure stands of sugar maple. Here nature was apparently "helped" by Indians, who girdled other trees to encourage the sweet-sapped maples. Outward from here, other species increasingly mix in. Yellow birch, the "second-in-command," needs somewhat more moisture, and its seedlings are somewhat less shade-tolerant than those of sugar maple. On lower parts of the ridges it shares dominance with sugar maple, and on Greenstone and Red Oak Ridges near Washington Harbor it takes over first place. White-cedar, perhaps third in importance, can tolerate both wetness and dryness. Therefore it occurs throughout the maple-birch area, and in many swampy places it becomes the principal tree. White spruce and balsam fir, the presiding species on most of Isle Royale, occur sparingly through the maple-birch forest, mainly on north slopes and in dips in the southerly slopes, where moisture accumulates. This forest, then, is distinctly a hardwood, deciduous forest. Intensely green in summer, skeletal in winter, it forms a striking contrast with the coniferous shoreline forests at the island's other environmental extreme.

Yellow-bellied sapsuckers drill rows of holes in trees and later return to feed on sap and insects. A sugar maple-yellow birch forest (right) occupies the south slope of Sugar Mountain.

Wherever sugar maple forms part of the overstory, it puts its structural stamp on the forest, as we saw on the warbler's knoll. It does this through prolific reproduction. So abundantly do its seeds germinate that the little maples often make a continuous cover over the ground, shading out most other plants. (The

few herbaceous plants that do survive in these forests are mostly species found in other forest types as well—such as Canada dogwood, twisted-stalk, bluebead lily.) In areas where the canopy is closed, intercepting most of the sunlight, the maple seedlings remain small, waiting until the day a big tree falls, giving some a chance to grow. (Such blowdowns are rather infrequent, since trees here are better anchored and less susceptible to heart rot than those in the spruce-fir forest.) Where the canopy is more open, the young maples form an understory, vying with each other for ultimate positions in the overstory. In such a situation (again as on the warbler's knoll), the ground beneath the sapling maples is nearly bare, though even here tiny maple seedlings manage to survive—a potential third wave, as it were. The maple's fantastic ability to reproduce is also demonstrated in some fringe areas, where scarcely a mature maple can be found. Going down the Greenstone Trail on the last long descent to Windigo, you see beneath the birches thickets of the irrepressible sugar maple.



With few conifers and only small amounts of combustible material near the ground, most of the maple-birch forest has escaped fire for a long time and has been able to reach maturity. For some animals that feed near the ground, this is a bad state of affairs. Deer mice find the pickings rather slim here. Hares, which need thick cover as well as low-growing plants to eat, generally are confined to the swampy coniferous pockets within the maple-birch area. Moose, though able to reach plenty of foliage, find very little diversity in the menu.

This loon's nest was built on a tiny island in Tobin Harbor.

This forest is much more generous to those animals that can reach its upper levels. Red squirrels can harvest maple and birch seeds and the many fungi that grow on old trees—trees that also offer them numerous nesting cavities. Birds, though perhaps less abundant and diverse here than in some of the other forest types, nevertheless occur in good numbers. Most of them feast on the insects that are feeding on the upper foliage. The great majority of birds escape the winter harshness by migrating south. Easily the most common are the oven-bird and the red-eyed vireo. The oven-bird manages to find insects on the leafy forest floor, where it builds its domed nest. The red-eyed vireo hangs its little basket nest in the fork of an understory branch, and feeds upward into the canopy. You can hear its monotonous question-and-answer phrases all day long.

Considered now to be a relict of an earlier warm-dry period, when they

were much more extensive, Isle Royale's maple-birch forests await the dictates of climatic change—expansion if the climate warms, extinction if it cools. Meanwhile they add pleasantly to the diversity of life and landscape on the island.

The Loon: Inland Lakes

It is noon. The sun shines warmly on the quiet water of Siskiwit Lake, sprawling in its great depression between the Lake Superior shore and Greenstone Ridge. The forest enclosing it stands tall and green on the south side, where aspen and birch have had 75 years to grow since the last fire; and short and green, with openings, on the north side, where the 1936 fire burned clear down the ridge to the lake. At either end, dark swamp conifers stretch back to other, smaller lakes. Circling high above the lake, gulls are moving dots of white.

Out near the middle of Siskiwit Lake, near Ryan Island, a loon dozes, bill tucked under his wing. Just off the shore of the island, his mate shepherds their two light-brown young. Like all young loons, they had taken to the water the day they hatched, but they still depend on their parents for food.

Having rested enough, the male wakes up and dives. Soon after submerging, he spies whitefish and ciscos; they are too far away to be overtaken. He continues down, into the dim world a hundred feet beneath the surface. Here,

just above the fine brown mud covering the bottom rock, he comes upon a lake trout. But it is too big. He angles up toward the light. On his way, a school of young ciscos flashes by. He spurts after them and catches one that lags. Continuing underwater, he swims to his family and breaks the surface with his prize. He mashes the cisco in his bill and passes it to his mate, who feeds it to one of the young.

As the male swims slowly away, six loons down the lake begin yodeling. Two pairs and two unmated birds have joined in a tight flock on the water and now circle around, calling crazily. The male, a mile away, wails in answer. With feet spattering and stiff wing-tips hitting the surface, he makes a long take-off, then arcs over the middle of the lake, where the other loons have congregated. But the instinct to feed his family is stronger than the social pull of his brethren. He turns and flies to the east end of the lake.

The common loon, shy of man and preferring wilderness lakes, finds favorable habitat in Isle Royale National Park.

Here the rock bottom slopes up and stream deposits lie in quiet coves along the shore, making shallow water where aquatic plants can grow, small fish can thrive, and snails, mussels, and leeches can find food. Among the many little islands, female mergansers and goldeneyes lead their broods. Along the shore, teetering spotted sandpipers search for insects. Crowding down almost to the water, green alders, ninebark, sweet gale, and white cedar make a dense shoreline fringe.

The loon finds good feeding here in the shallows. Much of the afternoon he flies back and forth from these quiet coves to his family with offerings of snails, leeches, and small fish. A mink hunts here too, leaving empty mussel

shells strewn along the shore. Among the horsetails, burreeds, spikerush, and yellow pond lilies, great long pike pursue smaller fish, seizing them in their saw-toothed jaws and gulping them into their cavernous mouths.

The hours pass. The sun turns red and sinks below Greenstone Ridge. Up in the young birches on the north side of the lake, a hermit thrush salutes the evening with liquid, ethereal song. In a small cove behind a rocky peninsula, beavers emerge from their lodge and make V's through the water, intent on foraging. Two bats flutter erratically over the lake, catching insects. Off toward Wood Lake, a loon utters a long, gull-like cry, sending echoes ricocheting across the water. Then, as if set off by this sound, a pack of wolves somewhere on the south shore begins howling. Punctuated by yips and barks, the voices rise and fall, saying something that needs to be said.

The male loon patters across the water, lifts into the air, and disappears slowly toward Siskiwit Bay, his stiff wings "putt-putting" like some distant outboard.

In some ways, Siskiwit Lake mirrors all the lakes of Isle Royale. It has the cold-water fish of the few deep lakes, and at its shallow ends it has much of the plant and animal life typical of the smaller, shallower lakes.

Of Isle Royale's 42 named lakes, four are oligotrophic; that is, they are cold, deep, and clear, and are poorly provided with nutrients. In addition to Siskiwit, they are Desor, Sargent, and Richie. The first three have one or more forms of the cisco-whitefish group; Richie does not. Siskiwit Lake also has the cold-water lake trout, which fishermen pursue in summer by bumping baits along the bottom. These lakes, because of their low levels of nutrients, support only small numbers of plankton (microscopic plants and animals). The rocky bottoms are too deep for much sunlight to reach them, and most of the shore is unprotected from wave action; thus there are few places favorable

to rooted aquatic plants. But on Siskiwit there are always a few sheltered spots that meet their requirements.

All the island's other lakes are classed as eutrophic or dystrophic. They are characterized by shallow, warm water colored by organic matter and tannic acid; high nutrient levels; and abundant plankton and rooted aquatics. In these lakes, the balance is being tipped in favor of plant over animal life. Among the many plants which take root on the bottom and send shoots above the surface or below it are spikerush, burreed, yellow pond lily, horsetail, northern naiad, cattail, and various kinds of pondweed.

With less diversity of habitats present, there are fewer species of fish in shallow lakes than in the deeper lakes. The dominant predatory fish are northern pike and yellow perch. White sucker, blacknose and golden shiner, and brook stickleback are common plant-feeders. The redbelly dace, finescale dace, and fathead minnow are particularly typical of some of the shallower, more stagnant lakes, such as Lily, Wallace, and Sumner.

In the shallow, quiet water near

Lake Richie (top), one of very few oligotrophic lakes in the park, is characterized by comparatively great depth and clarity and a poor supply of nutrients. About half of Isle Royale's lakes are eutrophic, like Forbes (above and top right). They support many kinds of plants, such as the insectivorous sundew growing on a log and the rooted cow lilies. Dystrophic lakes such as Moose (right) tend to be boggy and low in fish productivity.

lake shores you are also likely to find snails, mussels, and those friendless creatures, leeches, of which Isle Royale has about 15 species. Snails feed on algae growing on rocks. Mussels burrow part way into the sand or mud and siphon water, ingesting the copepods and other minute animals in it and pumping out the rest. Most leeches eat small animal life, such as insects up to about ¼ inch. Some species attach themselves to animals, including humans, and suck blood—which is why swimming in the inland lakes is not recommended. One very small species fastens onto the gills of fish. Along the shore of any lake you are apt to surprise green frogs, the island's commonest amphibian.

Several kinds of mammals and many birds that feed on aquatic life are found around the inland lakes. Moose are especially fond of aquatic plants, and beavers like them too. Mink restlessly search out frogs, snakes, fish, birds, and other small animals, while their larger, scarcer cousin the otter feeds chiefly on fish, pursuing them with marvelous, fluid speed. Muskrats, also scarce on the island, feed mainly on plants, but also eat mussels, other small aquatic animals, and carrion. On the larger lakes, red-breasted and common mergansers dive for fish, while goldeneye ducks may be found on almost any lake or beaver pond. Gulls keep an eye on all water bodies, and loons, which need a long run to lift their heavy bodies into the air, visit any lake with adequate take-off space.

Along shores, great blue herons stalk fish and other aquatic animals, spotted sandpipers hunt at the water's edge, and kingfishers dive for small fish from overhanging branches or from the air. Occasionally, ospreys may be seen at inland lakes, where from high in the air they plunge into the water for fish.

An open bog in the 1936 burn area and the bog on Raspberry Island represent early and late stages in succession.

Sadly, ospreys and bald eagles are disappearing from the island scene. They were once common here, but chemical pesticides that have been absorbed by fish, the principal food of these birds, have decimated both species. Lake Superior is not yet highly contaminated; the poison is probably mostly ingested farther south in winter. Ospreys and eagles build their big stick nests high up in trees, ospreys choosing dead trees while eagles use live ones. Some of the abandoned nests remain for years, slowly disintegrating.

Three of Isle Royale's lakes have witnessed the evolution of new species or subspecies. Siskiwit Lake, although only 50 feet higher than Lake Superior, has been separated from it for about 5,000 years. In this time, through small mutations and differential survival, the ciscos in Siskiwit Lake have changed enough to be considered a new species. In Sargent Lake, about 100 feet above Lake Superior, a subspecies, the Sargent Lake cisco, has evolved. Lake Desor can make sole claim to two subspecies: the Lake Desor cisco and the Lake Desor whitefish. And Lake Harvey has three—a pearl dace, a blacknose shiner, and a fathead minnow—all bearing its name. In the case of each lake,


SPHAGNUM ZONE
Pitcher plant
Bog rosemary
Leatherleaf
BOG FOREST
Tamarack
Black spruce
Balsam fir
White spruce
Paper birch
Alder
CLIMAX FOREST
MAT ZONE
Sundew
Labrador tea
Bog laurel
SEDGE ZONE
Buckbean
Bog loosestrife
Numerous sedges
WATER LILY ZONE
Water lilies
Submerged plants
Humus
Bog bottom
Sundew
Sedge
Bog laurel
Ladies'-tresses
Buckbean
Leatherleaf
Pitcher plant
Bog rosemary
Spatterdock

isolation from Lake Superior and other inland lakes on the island prevented the intermixing of populations that would have kept them genetically uniform. Why *all* the species in these three lakes did not develop into new forms will probably remain one of the mysteries of evolution.

For all their specialized forms of life and apparent permanence, lakes are nevertheless one of the more ephemeral features of nature. They die partly through the downcutting of their outlets, which lowers the surface of the lake; but the chief agents of death are siltation and spreading plants. Wherever the water is shallow and quiet, aquatic plants take root. On the shallower lakes, a floating mat of vegetation may develop and eventually cover the surface. Water lilies, spikerushes, and others we have mentioned begin the process. As the vegetation becomes denser, trapping more and more silt and organic debris, sedges begin to form a mat on the surface. Gradually this sedge mat extends farther and farther out over the water, as dead plants and roots help to fill in the space underneath. As the shoreward parts of the mat fill in and become somewhat drier, sphagnum moss often begins growing on it. Whether sphagnum appears or not, shrubs soon become established; leatherleaf, bog rosemary, and alders are the most common. Where sphagnum is present, Labrador tea usually takes root, eventually choking out the other small shrubs and much of the sphagnum as well.

As the sedge mat continues to grow out over the lake, succession progresses on the landward parts. Debris from the plants helps to build soil, and certain trees become established. Where the soil is slightly acid, black spruce becomes the dominant species. Where it is slightly alkaline, white-cedar is more prevalent. Sometimes a few tamaracks also grow in these bog forests.

Eventually, as the soil builds and dries, the "climax" species become established. Since most lakes and bogs on Isle Royale are at the lower elevations, these species usually will be white spruce and balsam fir. When this stage is reached, all influence of the former lake is gone. It is truly dead.

On Isle Royale you can see all phases of lake extinction. Hidden Lake, for instance, at the start of the Lookout Louise Trail, has an irregular fringe of bog mat. Lily Lake, in the southwest part of the island, is

The osprey, whose survival has been threatened by environmental pollution, adds a note of excitement to the Isle Royale scene. This nest, like most osprey nests on the island, was built in the top of a tree killed in the 1936 burn.

half closed over with a classic floating mat. Walking on it you can feel it spring up and down. Growing on the spongy surface are specialized plants such as sundew, pitcher plant, and certain orchids such as rose pink and ladies' tresses. At Raspberry Bog, on Raspberry Island, the mat has closed completely. A boardwalk nature trail here takes you through successive zones—from black spruce to Labrador tea to leatherleaf—that represent phases in formation of the bog. And looking down from almost any ridge, you can see dark conifer swamps. Some of these may stand in place of former lakes. You are witness to yet another aspect of change on ever-changing Isle Royale.

Some lakes, however, will resist a very long time. The larger and deeper a lake, the longer it will take to fill. Depth is an obvious deterrent, but large surface size slows the filling process in less obvious ways. Over lakes such as Siskiwit, Desor, and Feldtmann, the wind sweeps unobstructed, building up large waves. These discourage establishment of aquatic vegetation. And during warm spells in winter, the ice cover expands, pushing out over the shore and bulldozing anything in its way.

Ten thousand years from now—to be optimistic in more than one way—our descendants may still hear loons wailing on the broad waters of Siskiwit Lake.

The Beaver: Ponds And Streams

The trail crew doesn't know it, but they have helped the beavers. Alongside the trail leading into Chippewa Harbor the beavers have created ponds. Some of the aspens they cut fell across the trail, and the trail crew has had to saw off the blocking trunks and branches. This has saved the beavers a lot of work. Now they are simply dragging the branches to their pond and consuming the tender parts. Floating in the water near shore, each beaver takes the small end of a branch in its front paws and feeds it into its mouth. "Crunch, crunch, crunch"—several leaves and a few inches of stem disappear. More quietly the beaver then chews this mouthful to a pulp and swallows it. "Crunch, crunch, crunch"—the next piece gets processed.

This beaver family—father, and mother with last year's and this year's young—indeed have been living amidst plenty. In the past few years they have worked down along a small stream, building a succession of ponds between two low rocky ridges crowned with jack pine. Their current lodge is

in the middle of the last pond, secure from invasion. From this lodge they can travel up through their six ponds, now in summer harvesting mostly herbaceous plants and thimbleberries on shore, and in spring and fall any of the numerous aspens and birches that grow in the surrounding forest. Up to a point, that is, for the farther they venture from the water the more vulnerable they become—each foot of distance from the safety of the pond increases the chance that a wandering wolf might catch them. Thus far, with plenty of trees left, they have cut no farther than a hundred feet from shore. At the head of the uppermost pond, however, they have dug a channel 150 feet long to allow them to reach some particularly big aspens.

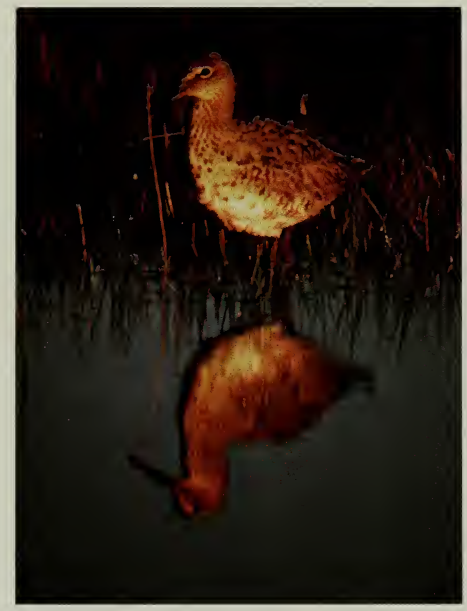
With many aspens—their favorite food—and many birches around, the beavers have been wasteful. Inevitably, some of the cut trees lodged against their neighbors, but even on trees that fell to the ground, many accessible branches have not been used. The beavers cannot afford this profligacy for very long, because they have reached the dammable limits of the stream. It trickles through their lowermost dam, across the trail, and down a steep hillside. Upstream from their six active ponds, they or their ancestors have already exploited the forest, leaving a series of old grassy ponds and wet meadows. Some birches but few aspens remain in those areas.

As the beavers chew aspen branches this rainy afternoon in late July, other creatures are also using the pond the beavers have made. Like knots on old logs that lie in the water, grey-brown goldeneyes and hooded mergansers sit motionless. Now half-grown, they have known no other world than these ponds, criss-crossed with fallen trees and the white reflections of still-standing

birches killed by the water. On other logs, painted turtles rest like stones. In the leaf-filled shallows along shore, green frogs, too, sit still. But some creatures, like the beavers, are on the move. Garter snakes crawl slowly along the pond edge, hunting frogs. A muskrat swims away with some of the beavers' aspen twigs. A solitary sandpiper, resting at the pond in its late-summer migration south, flutters up with a sharp "peet-weet!" as the muskrat passes. Between the two rock ridges flanking the ponds fly birds of the forest—blue jays, gray jays, woodpeckers, chickadees. The pond is indeed a focus of life.

As afteroon becomes evening, a cow moose wanders over the ridge with her calf. From the opposite direction—up the hill from Chippewa Harbor—comes a spike-horn bull, his one-pronged little antlers fuzzy with velvet. He sloshes through the upper ponds, being careful to avoid the cow. But now all the moose freeze. They have heard a deep bark from down on the trail to Lake Mason. Silently they melt back into the forest. A few minutes later the gray forms of wolves appear at the pond's edge. They sniff along and they listen for the sound of a beaver chewing. But all the beavers are in the pond. The wolves lap at the water, then trot up the trail toward Lake Richie. Their hunt has just begun. Slowly, pausing often to test the air, the parent beavers swim toward shore to begin the night's harvest.

On Isle Royale, wherever there is water deep enough to dive in, or a trickle that can be dammed, there are likely to be beavers. They inhabit protected Lake Superior shorelines, most inland lakes, and a multitude of ponds of their own making. As of October 1969, an estimated 750 to 1,000 beavers lived on the island, concentrated mainly on the lake-dotted northeast half. Historically, this is a high number. In the 1940's and 1950's numbers were much lower, presumably because of an epizootic disease such as tularemia. In the 19th century, as we have seen, beavers were gone, or nearly so.



The greater yellowlegs is one of many wild animals that benefit from the engineering activities of beavers on Isle Royale. These ponds were established by beavers on Indian Portage Creek, near Chickenbone Lake.

No other animal, including the moose, has as much ecological impact on Isle Royale as the beaver. For this big rodent creates a new environment wherever it goes. When beavers enter virgin territory to build a dam (which still happens on Isle Royale, though old, regrown pond sites are usually available), they kill a section of forest by flooding. This drives out terrestrial animals and most of those inhabiting the trees. Around the shores of the ponds they open the forest further by cutting shrubs and trees, particularly aspen and birch.

While the beavers are destroying forest habitat, to the detriment of some animals, they are creating new habitat for others. The habitat for such quiet-water fish as white suckers, brook sticklebacks, golden shiners, and blacknose shiners is greatly expanded. Frogs and painted turtles find new territory, while frog-hunters such as garter snakes and minks are given new hunting grounds.

Beaver ponds, in fact, afford some of the best wildlife watching on the island. Creep up to any pond, sit quietly, and you are bound to see something interesting. Maybe it will

be a moose, come for aquatic plants. Perhaps you will see the makers of the pond themselves, eating, grooming, or working on their dam or lodge. And always there will be birds about. If you have arrived stealthily, you may get good looks at mallards, black ducks, teal, goldeneyes, hooded mergansers, or ring-necked ducks. In the first half of summer there will probably be tree swallows, coming and going from their woodpecker-hole nests in dead trees. A kingfisher or great blue heron might be fishing there. Watch for cedar waxwings, kingbirds, or olive-sided fly-catchers snatching insects from the air over the pond. And listen for song sparrows and swamp sparrows singing from the marshy fringes.

Each beaver pond is different, not only in its activity at any given moment, but also in its situation and appearance. If the valley is deep and narrow, the pond will be deep and narrow, as in the case of the ponds described near Chippewa Harbor. If the valley is broad, with gentle slopes, the pond will be shallow, with much vegetation in it. If the pond is fairly new, it will probably have many dead trees or even some live ones standing in it; older ponds will be more open. A new pond created at an old pond site, where a meadow has developed, may be dotted with islands of grass and sedge. Some ponds are large; others are small. On a tiny rivulet I saw one that was five feet wide and eight feet long—a useless monument to the beaver's eternal dam-building urge.

When a beaver colony exhausts the food supply at its pond, it moves to a new site, allowing a reclamation process to begin at the old one. Without attention, breaks in the dam allow the pond to drain, leaving a bare, muddy surface. This is soon invaded by annuals and short-lived perennials, such as touch-me-nots, loosestrife, Joe-Pye-weed, raspberry, sedges, and rushes. These gradually give way to bluejoint grass, which covers not only the old pond bottom, but also the remains of the dam and lodge. Very slowly, speckled alder extends its control from the edges toward the center. In these early stages of succession, red-winged blackbirds, swamp and song sparrows, and short-billed marsh wrens are given new nesting areas. After many years, if another beaver colony does not occupy the site, the surrounding forest may

succeed in reclaiming its former territory. This last phase is exceedingly slow, however, because the dense cover of grass and shrubs, as well as adverse chemical conditions in the soil, discourages tree establishment. Thus, beavers may be viewed as agents of diversification, working against the forest's trend toward uniformity.

Of all the beaver's relationships with other animals, perhaps most important ecologically are those with the moose; and the moose gets much the better of it. The ponds provide moose with aquatic plants, which contain minerals they can't get elsewhere. But each bite taken by moose means several less for beavers, which also like aquatic plants. By cutting aspens and birches, beavers provide moose with tree-top foliage and bark they could not otherwise reach and with root sprouts sent up by the cut trees. So intense is the browsing, and so great is the competition from shrubs and conifers, that most of the resprouting aspens are killed, thus depriving beavers of a new supply of their primary food source.

The streams of Isle Royale, which offer beavers so many possibilities for ponds, constitute in themselves yet another type of environment. Sluggish streams, particularly those flowing through meadows or marshes, have much the same kinds of life, though less of it, that beaver ponds have. The more rapid streams harbor sculpins, white suckers, longnose dace, and sometimes brook or

Touch-me-not, or jewel weed, grows along the borders of streams and in other wet soils.

< The Canada goose is seen during spring and fall migrations.

< The painted turtle is one of many animals benefiting from the activities of the beaver.

rainbow trout. Washington and Grace Creeks have both resident and spawning trout. The Little Siskiwit River is also known for its brook trout. In the spring, thousands of white suckers and smelt run up many streams to spawn.

Most of the water draining off Isle Royale first flows quickly in little brooks down ridge slopes, then turns sluggish as it reaches valleys and drains through swamps and beaver ponds toward Lake Superior. Waterfalls are few, those on the Little Siskiwit River and Siskiwit Lake outlet being among the better known ones.

Oddly enough, at the mouths of some Isle Royale streams that empty into long harbors or bays, the flow alternates between downstream and upstream. In most of these cases, the flow shifts direction every 10 to 30 minutes. This phenomenon is not well understood, but it is not tidal. It is thought to be caused by the periodic building up and release of water at the heads of the harbors. Wind, if it is blowing up-harbor, and stream discharge cause the water to build up. Periodically, the build-up becomes great enough to cause a down-harbor shift, thus allowing the stream to flow in its normal direction. Washington and Tobin Creeks and the Big Siskiwit River exhibit this phenomenon quite markedly. Over Lake Superior as a whole, differences in atmospheric pressure cause similar, though less regular, effects. Such oscillating waves, known as seiches, occur in many lakes, bays and gulfs of the world.

As we have seen, the watery lowlands of Isle Royale provide for the needs

of many forms of life. Let's climb now to a very different sort of place, where heat, dryness, wind, and lack of trees call for different strategies by other kinds of creatures.

The Sparrow Hawk: Open Ridges

Even at 6 o'clock this early August morning, the sun is hot on Greenstone Ridge. Rising red above Lake Superior, it sends its rays unopposed against the open, rocky slopes, further drying the grasses and slowing the activity of animals.

But though it is hot on the open ridge east of Mt. Ojibway, there is some action. Perched in a hazelnut thicket, a song sparrow sings. In another thicket, a red squirrel rustles, searching for curve-beaked hazelnuts. Atop yet another, a Traill's flycatcher gives its short little call, advertising its territory, though its young and those of other flycatchers are on the wing and wandering. In the Greenstone Trail between two thickets a snowshoe hare nips wild strawberry leaves. Far down the slope, a red fox picks its way between the shrubs, alert for hare, bird, or mouse; if unsuccessful, it will descend into the forest for wild sarsaparilla berries—a never-failing resource this time of year.

At the tip of a dark spruce tree, a young sparrow hawk perches awkwardly, crying for food. But the hawk's parents are busy hunting. The trim female

sits on the limb of a dead aspen, studying the ground. Her sharp eyes scan the rocks, grey-green with lichens and crevice-lined with grass and bush honeysuckle. Out of the grey-green-brown background she discerns an interesting shape. She plummets to the rock and seizes a grasshopper in her talons, then returns to her perch. Seeing all this, the young bird flutters to the aspen, but approaching the limb too fast can't hold on and pitches forward. It circles around, and on the second try manages to land. The mother bird rewards it with a mangled grasshopper.

Grasshoppers, along with mice, are favored prey of the sparrow hawk.

The male sparrow hawk cruises above the ridge toward the fire tower, now flapping, now gliding, now hovering to inspect something below. He sees many things, but not all are significant to him. In a thicket of red maple, juneberry, and hazelnut a dark brown shape resolves into a bull moose intent on getting a last few mouthfuls before the heat drives him down into the forest. Across the trail, an oval depression remains in the grass where the bull slept part of the night. Farther along, the hawk sees two sharp-tailed grouse pecking at flower buds, berries, and insects. The grouse, too, will soon seek shade. Briefly, the sparrow hawk slows in his flight as he passes over a family of flickers stabbing the ground for ants, a cedar waxwing flycatching in the air, a robin caroling one last time this morning. But these are all too big for the hawk. He speeds on, searching for a sparrow, warbler, grasshopper, deer mouse, or red-bellied snake.

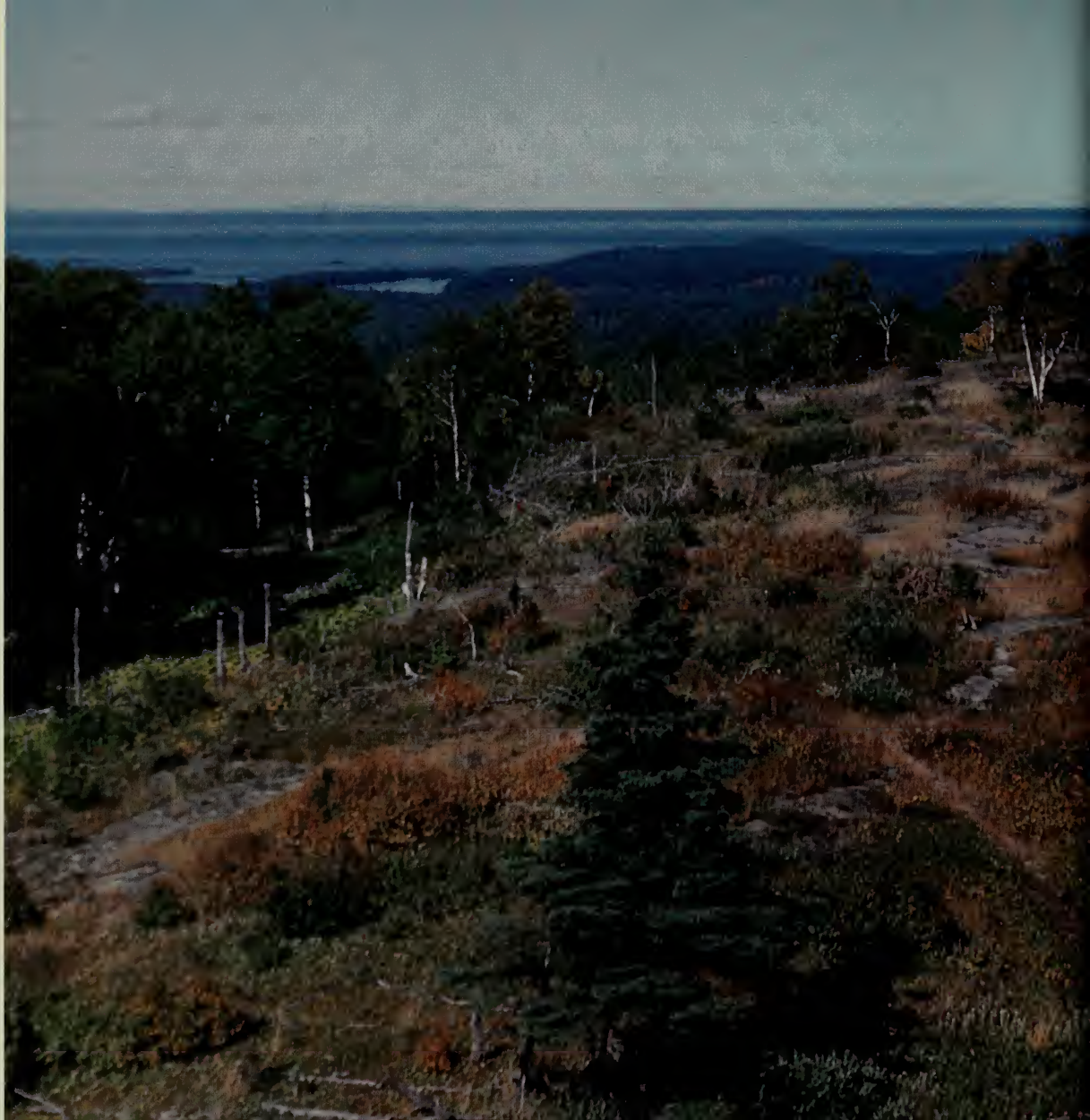
Then a dark shadow crosses the ground. The sparrow hawk looks up, climbs, then dives on the much larger red-tailed hawk. The redtail evades the rush and hastens on, eager to be free of its small tormentor. The sparrow

hawk pursues it as far as the fire tower, then turns and glides back toward his family. The sun highlights the reds and blues on his back and wings.

Far out and below the sun, white cottony fog creeps across the surface of the lake. Soon it will envelop the island, blotting out the ridges and valleys, the lakes, the forest. Today fog, tomorrow wind, next week a storm will interrupt the heat that prevails on the summer ridges.

This piece of Greenstone Ridge is one of the larger open areas on Isle Royale. Similar openings occur frequently on other parts of Greenstone Ridge and on Minong and Feldtmann Ridges, with small patches scattered elsewhere. Generally, these nonforested strips are the result of fire aided by erosion and drought. Ridgetops, being the highest land on the island, frequently are hit by lightning, which sometimes starts fires. After a fire, the denuded soil is easily eroded. On any slope, erosion continually occurs on a small scale, but the lower parts also continually receive soil from upslope. On a ridgetop, of course, there is no higher source. Here, creation of new soil must proceed faster than erosion in order to make any headway. Organic debris is the principal building material of soil on ridges, but vegetation is discouraged by the thinness of the soils and the dryness caused by steep slopes, sun-heating, and wind. If plant succession does proceed toward forest, fire promoted by the dryness may at any time set it back. Thus, the ecologic dog has itself by the tail, and some stretches of ridgetop may remain open for many years.

The plantlife on open ridgetops is mainly that characteristic of early stages of succession, as described in chapter seven. Such places are usually a patchwork of bare rock, grassy areas with small shrubs such as blueberry and bush honeysuckle, shrubby thickets of hazelnut, juneberry, and sometimes young red and sugar maples, and scattered trees representative of the surrounding forest.



The animal life is also distinctive, and some species are restricted to such open areas. The larger animals are those found throughout the island. Moose most often visit the open ridges in early spring, when some herbaceous plants are sprouting and two favored shrubs, hazelnut and juneberry, are leafing. Hares enjoy the abundant low growth throughout the year but particularly in the green seasons. Wolves take advantage of the easy traveling on ridges, turning aside when a moose is started. Red foxes hunt fruits as well as live prey. Red squirrels sometimes visit the thickets, apparently for their seeds and fruits.

On the other hand, many of the birds of open ridges are pretty much restricted to this type of habitat. Sparrow hawks, which rely heavily on large insects such as grasshoppers, are typical inhabitants, often nesting in old flicker holes in dead white pines. Chipping sparrows, bluebirds, starlings, robins, cedar waxwings, and chestnut-sided, mourning, and Nashville warblers also favor this kind of environment.

The sharp-tailed grouse, though uncommon, is perhaps the most typical bird of this environment. These large, grey-brown birds with short, pointed, white-fringed tails would disappear if forest claimed the entire island. Though good habitat for them is available, their presence on the island is still something of a mystery. The other grouse of the mainland—ruffed and spruce grouse—have not been able to colonize the island because they can't make flights of more than a half-mile or so. How did the sharp-tailed grouse manage it? Possibly it was introduced by islanders of the past who wanted a game bird to hunt. More likely, the sharp-tail, a stronger flier than the other grouse, came under its own power, alternately sailing and beating its short, rounded wings.

Isle Royale's ridgetops thus offer the hiker the opportunity to explore a distinctive environment in all stages of plant succession from bare rock to mature forest. He will enjoy wild strawberries in early summer and blueberries in late summer, as well as incomparable views of the island, the big lake, and the mainland hills; and he will experience the ever-changing weather that presides over all.

The Time Of Testing

Snow. Ice. Wind. Birches bare lines against the sky. Conifers green and full on the white hills. Silence. Now wind again. Hare tracks frozen across the trail. This is winter, the time of testing.

Bringing cold, wind, snow, and reduced food and cover, winter is indeed the most critical time of year for life on Isle Royale. But the island's plants and animals have a long time to prepare for it, since the slow-cooling water of Lake Superior warms the cold air above it until ice forms on the lake.

Fall may be considered to begin in August, when island birds begin migrating, and to end in late November, when snow usually falls in earnest. In mid-September, maple leaves start to turn red and yellow, and birches add their gold. Colors peak in the first half of October, as aspens, too, turn yellow. Then, with the first good wind, leaves fall. In October, brook trout, lake trout, and whitefish spawn. Moose, too, end the year with reproductive activity. The bulls have been getting more and more edgy since early September. They rub the velvet off their antlers in early September, and track down cows through

The period of late autumn and winter brings strong winds as well as low temperatures to Isle Royale.

late September and October. Their calls and grunts resound through the fall forest. Meanwhile, insect numbers have been diminishing rapidly. Mosquitoes have died out during August, flies in September. Most other insects are killed or go into hibernation during the frosts of September and October. Monarch butterflies, however, flutter south across Lake Superior toward the Gulf of Mexico, obeying the yearly command that pulses through their tiny nervous systems.

By late November, when the white winter blanket has settled, plants are dormant; insects, reptiles, and amphibians are hibernating; and most birds have migrated. Most of the mammal contingent, however, faces winter head-on.

Of Isle Royale's current 15 species of mammals, only the bats hibernate or migrate to the south. To survive the winter, all others must find food and must themselves avoid becoming food for something else. Of Isle Royale's 120 or so species of summer birds, however, only about 20, joined by a few species from the Arctic, stay through the winter. These few birds and mammals are all that remains to enliven the elemental scene at this difficult time of year.

The conditions these animals must face vary from winter to winter, but always they are severe. Temperatures usually range between $-25°$F and $+40°$F. Frequent strong winds, generally from the west, add greatly to the chill of low temperatures. Snow depths range from one to three feet, with

less under dense conifers and considerably more in drifts. Crust conditions within or on the snow sometimes help but more often hinder animals. Taken together, all these conditions make great demands on the energy of animals, at a time when food is in shortest supply.

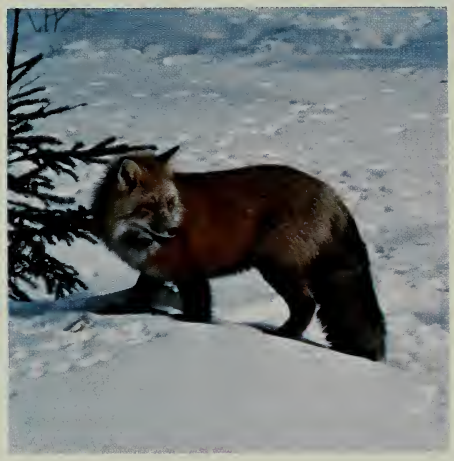
Over millenniums, northern wildlife has evolved various strategies for survival. Birds, with the power of flight, can go long distances to find food. In winters when birch seed is abundant, redpolls, pine siskins, and goldfinches may remain on the island in large numbers. In poor years they may wander in search of more productive areas. The same strategy is used by other northern finches, such as pine and evening grosbeaks, purple finches, and crossbills, depending on the supply of mountain-ash fruits, pine seeds, and other food. Birds that rely more on insect eggs and larvae—such as chickadees, blue and gray jays, and woodpeckers—have a more dependable source and consequently remain on the island in fairly stable numbers from one winter to another. Along the south shore, where the lake is usually open, a few mergansers and goldeneyes sometimes gather to feed on fish and other aquatic life. The ducks thus hunt in an environment that is usually considerably warmer than the air above. A few birds of prey, such as goshawks, horned owls, and in some years the snowy owls of the Arctic find enough birds and small mammals to tide them over.

Plant-eating mammals, which are prey species, have developed highly individualistic methods for coping with winter and its predators. Deer mice and red squirrels lay up provisions during the long fall in numerous caches—in trees, logs or underground. Mice and squirrels store mostly seeds of various kinds, though squirrels may rely on fungi and birch and alder catkins in years when

The fruits of mountain-ash provide a reserve of winter food for many animals, including the red fox.

conifer seeds are scarce. For these little animals, the snow is a blessing, providing them with covered runways hidden from most predators and with insulation from the chill air above.

Beavers have a winter system of living that insulates them almost completely from atmospheric rigors and the danger of predators. Before ice forms, they cut branches of aspen, birch, and other favored foods and stick them into or weight them with stones on the bottom of their pond or lake, usually near the lodge. They plaster their lodge with a new layer of mud, leaves, and sticks. When winter's cold spreads a layer of ice over the water and freezes the mud on his house, the beaver is effectively sealed in, and winter and predators are sealed out. When he gets hungry, he leaves his lodge through an underwater entrance and visits the food cache. Occasionally, however, he may leave the confines of his home and pond to gnaw the bark from a tree felled in the fall. At such times he risks being caught by the wolf pack or perhaps by some half-starved lone wolf rejected by the pack and unable to kill moose.



For the red fox, winter is the critical season for survival on Isle Royale.

Muskrats lead a much more hazardous life. They do not store food for the winter, and though they feed upon aquatic plants and some animals beneath the ice, they also venture out for land plants. While foraging, they are under threat from virtually every predator on Isle Royale—mink, otter, weasel, red fox, wolf, lynx, and large hawks and owls. Perhaps it is only his caution and unspecialized food tastes that allow any muskrat to survive the winter.

Cover is surely the prime winter concern of the snowshoe hare, for in most areas the supply of woody stems and twigs is adequate for his dietary needs.

When winter strips away the deciduous leaves and green ground cover, the hare cannot safely wander as far as he did in summer. White-cedar swamps become headquarters for many hares, since they provide dense, low foliage that can also be eaten. On Isle Royale the hare's chief enemy is the red fox; the lynx, its principal predator through much of the north, is so rare here that it is hardly a threat; and the wolves concentrate on moose. Hares rely on their speed and their broad, snowshoe feet to escape foxes. If the snow is soft, foxes will sink in farther than hares during a chase, but if a crust has formed the chase is more even. Its change in winter to a camouflaging white coat also aids the hare in its struggle to survive.

And what about the moose, that huge beast that eats more and provides more food for predators and scavengers than any other animal on the island? Snow depth seems to be the moose's main concern, since it affects ease of travel. During winters with deep snow, moose concentrate near shorelines, where the abundant conifers intercept much of the falling snow and also provide browse. In these forests moose can also feed on twigs and bark of aspen, birch, and mountain-ash—among their favored foods. Frequent blowdowns put more food within reach. Deep, soft snow is more easily navigated by adult moose than by wolves, though calves are seriously hindered. A crust on or within the snow probably aids pursuing wolves. It seems, then, that food sources and snow depth regulate the moose's winter wandering, and that wolves are accepted as an environmental hazard. Healthy adult moose, in fact, seldom need to fear wolves; calves and infirm adults are the usual victims.

Predators, too, are faced by a reduced food supply in winter. Insects, reptiles, amphibians, and many birds have died, hibernated, or gone south. The young of various mammals are not as abundant as in summer, having been reduced by the many hazards of their environment. The remaining prey animals spend more time in dens. Most predators, therefore, are forced to hunt farther and longer for a meal. The island's few otters, for instance, must follow streams for miles, diving in where fast water keeps ice from forming, and searching for fish and crustaceans as far under the ice as their lungs will allow.

< Redpolls and purple finches may remain on Isle Royale through the winter when the supply of birch and other favored seeds is good.

Timber-wolf tracks follow the shore of Siskiwit Bay.

In winter, red foxes depend heavily on hares; and, as we have seen, catching a hare in the snow is no easy job. In years of good mountain-ash crops, foxes, as well as ravens and other wildlife, eat many clusters of the orange-red fruit. As we will see shortly, foxes are also inadvertently assisted through the winter by wolves.

The wolf's only real source of food in winter is the moose herd. Hares and smaller animals are hardly big enough to justify the energy expended in catching them, and beavers seldom venture ashore in that season. Possibly, wolves have an easier time finding and killing moose in winter than in any other season. Wolf packs hunt by following the easiest routes—usually on the wind-swept ice along shorelines, but sometimes inland along previously used routes. The wolves trot along, usually in single file, until moose or fresh tracks are found. If a discovered moose stands its ground they usually soon leave, wary of the animal's dangerous hoofs. If the quarry runs, they chase it, single file. If deep snow, thick cover, or a long head start prevents them from catching up with the moose in a short time, they abandon the pursuit. But somehow they recognize weakness, and keep after infirm individuals. Attacking mainly the rump, they slow the animal down, eventually bring it to the ground, and then quickly kill it. Some victims, however, are merely wounded and left to weaken, and are killed later. After a kill, the wolves gorge, rest, then usually feed intermittently until the

last bones are gnawed. A day or two after killing a calf, or several days after killing an adult, they are on the move again, seeking more fuel for their ever-burning bodily furnaces.

A kill has ecological importance that goes far beyond the survival of wolves. For when wolves leave a carcass, temporarily or permanently, other animals come for a share. Red foxes, particularly, congregate at a kill, for the moment forgetting their territorial animosities. Ravens, it seems, make most of their winter livelihood from wolves. They actually follow wolf packs on the daily rounds, picking some sustenance from feces left by the wolves, and waiting for them to make a kill, from which they later get a meal or two. Gray jays and blue jays, smaller cousins of the raven, also visit moose carcasses for scraps. Tiny chickadees pick at the bone marrow where the opening is too small for ravens or jays. Deer mice undoubtedly gnaw the bone marrow, and red squirrels may sometimes make use of the kill. Thus several kinds of animals ride through winter partly on the coattails of the wolf.

The three scavenging ravens are members of a flock that follows the wolf pack.

Just as fall is prolonged by the warming effects of Lake Superior, so spring is delayed by the water's slow adjustment to the temperature of the air above. The patches and solid sheets of ice that form on much of the lake are slow to break up. When they finally do, the cold water continues to cool the spring air masses flowing over the lake. The shore ice usually goes in April, although some years it persists until May. On May 3, 1972, when *Ranger III* made its first trip of the year, it had to break ice in Rock Harbor for several hours before it could reach Mott Island. That day, the snow lay 5 to 8 feet deep

behind the National park headquarters building.

During May, tree leaves begin unfurling; skunk cabbage, hepatica, and other early flowers bloom; smelt and suckers swarm up streams to spawn; birds return *en masse* from the south. By mid-June, when the trees are usually fully leaved and many forest flowers are blooming, summer can finally be acknowledged.

Wolves, Moose, And The Balance Of Nature

Through the cycle of the seasons, and over decades and millenniums, this tree-clothed rock we call Isle Royale has experienced and still experiences change of great magnitude. Between seasons, whole populations of plants and animals come or go or change their mode of existence. Over years, fire and wind unpredictably strike, for a while drastically altering the face of the landscape; and populations of living things fluctuate, sometimes violently. Over centuries, slow climatic change brings new assortments of plants and animals. Yet the island remains a green place teeming with life, and the diversity of life on it perhaps continues to grow. How does all this individual change result in a collective stability, and can we find in this ecological drama some lessons for our own species?

The now-famous story of the island's wolves and moose can begin to show us how the Isle Royale web of life hangs together. Sometime in the first decade of this century, it seems, moose became established (or re-established) on the island. This significant happening was probably related to a regional

change in the vegetation. Between 1890 and 1910, logging and fires in the northern Great Lakes area destroyed much of the reindeer lichen, on which caribou heavily depend, and created open areas where tree seedlings and shrubs—food for deer and moose—could flourish. Consequently, caribou decreased and deer and moose increased. Isle Royale's moose immigrants, which probably swam singly or in small groups from the Canadian mainland, were perhaps pressured by a growing population to seek new feeding grounds. As sometimes happens when a new species reaches an island with suitable habitat, an irruption followed. By 1930, when Adolph Murie studied the situation, the moose population had reached an estimated 1,000 to 3,000 animals, and a large part of the woody vegetation within their reach was overbrowsed. Murie correctly predicted that starvation and disease would soon decimate the herd.

The first large die-off occurred in the winter of 1933. By 1936, when fire burned a quarter of the island and further reduced the browse supply, moose numbers had dropped to

Depending mainly on moose, Isle Royale's wolves also prey upon the snowshoe hare. A wolf pack withdraws (right) after an unsuccessful attack on a cow moose and a yearling.

an estimated 400 to 500. From this low point, the herd increased again, aided by luxuriant resprouting on the burned area. By the later 1940's there were numerous signs that die-offs would again occur.

Boom-and-bust cycles might have continued had it not been for the arrival, in the late 1940's, of the timber wolf. Through the first half of the century its smaller cousin, the coyote, had been present; but coyotes do not prey upon moose. By 1957, somewhere between 15 and 25 wolves inhabited the island. Coyotes, probably killed off by the intolerant wolf, had disappeared. In 1960 David Mech, a Purdue graduate student studying wolves for a doctoral dissertation, determined after many hours of aerial observation that the wolves numbered 21 or possibly 22. This population was composed of a large pack of 15, which hunted mostly on the southwest two-thirds of the island, and small groups of two or three that hunted mostly on the northeast one-third and along the north shore.

From an aerial census made in March 1960, Mech estimated the moose herd at 600. Apparently the wolves were controlling the herd at a level below that at which the food supply would control it, for browse species were growing in areas where they had not been evident for decades. Furthermore, the calculated annual kill of adults by wolves was nearly equal to the calculated number of yearlings surviving to join the breeding population each spring. And apparently the herd was healthy: the proportion of cows bearing twins as opposed to a single calf was much higher than it had been in the 1930's —a sign of good nutrition.

Research in the late 1960's and early 1970's indicated that the moose herd may have increased. An aerial count in mid-winter, 1972, produced an estimate of about 900 animals. Counts of moose pellets by researchers from Purdue and Yale suggested that the population in the early 1970's was 1,000 to 1,500. Wolf numbers remained in the low 20's. Thus it appeared that a slow rise in the moose population was underway, though wolves had not decreased.

Although wolves certainly have a damping effect, the ultimate determinant of moose numbers is the island's food supply. That supply depends on the

stage of forest succession and the extent of browsing by moose. The relationship between these two factors is delicate and complex. In many parts of the northern forest, succession proceeds to a stable state in which spruce and fir form a closed canopy. In the course of this succession, food for moose declines as trees grow above browsing height and some favored browse species are shaded out. On Isle Royale, where moose densities are among the highest known and where wind takes a large toll of trees, succession seldom proceeds to a pure spruce-fir stand. The toppling of trees creates openings in which shrubs and saplings spring up, producing much browse. Browsing is so heavy in many of these areas that the young trees cannot grow up. This maintains a good food supply for a long time but eventually can result in elimination of the browse species and replacement by grass and unpalatable shrubs or by spruce. If it continues, such heavy browsing will cause certain tree species to drop out of the forest: mountain-ash essentially everywhere, aspen and cherry almost everywhere, paper birch and fir in many areas, and yellow birch in some areas. Only fire or a major decline in moose numbers will break this trend: major fires create so much new growth that moose cannot suppress it all; and a population decline has a similar effect. Thus the moose population cannot be expected to stay indefinitely at its present high level without the advent of fire.

Just as available browse limits moose numbers, available moose would ultimately limit wolf numbers. But there is considerable evidence that social pressures may set an upper limit to wolf density, even when the food supply goes on increasing. Within each pack there is a "dominance order;" each animal knows its social standing with respect to all the others. Furthermore, there are separate dominance orders among males and females. Normally, the lead, or alpha, male mates with the alpha female. Matings between subordinate animals are often prevented by the lead pair. As a pack grows, sexual rivalries tend to become more and more complicated, and stress increases. Reproduction may also be inhibited by the dominance of large packs over smaller ones. If the territories of such packs are not well separated, the small pack probably has no chance of raising pups. Thus as wolf numbers grow

in an area, increasing social controls apparently restrict reproduction.

Death of pups is another, perhaps greater, control on numbers. On Isle Royale, between 2 and 5 females are fertilized every year. This would produce a rapid population growth if it were not for the high mortality rate of pups. Many pups die during the denning period, for causes not yet well understood. Others succumb after leaving the den. If a pup survives its first 6 months, or until fall, its chances of living several more years are good.

Though wolves have the potential to reproduce rapidly, and sometimes do so after heavy reductions, in most wolf populations the proportion of pups is small. This is the case on Isle Royale, where the density of wolves, about 1 per 10 square miles, is one of the highest known. This is possible only because of a very high moose density of 40 to 50 per 10 square miles. At present, the wolves apparently are holding moose numbers steady or to a slow rise, and environmental and social factors are keeping wolf numbers stable.

Among Isle Royale's other animals, there are examples of both stable and unstable populations. The red squirrel population, though high, does not change greatly. As we have seen, this species has no really efficient predator, like the marten, on the island. Its numbers are regulated largely through reproductive control. Females bear only one litter, averaging three young, in a year, and many do not reproduce at all in poor cone years. Thus the birth rate is low, the survival rate is high, and the chatter of red squirrels remains perennially ubiquitous.

Deer mice, though without competition from other small mammals except red squirrels, remain rather thinly distributed over the island. In favorable habitat, there are only 1 or 2 per acre. This low density, which is comparable to that on the mainland, must represent the limit allowed by available food and shelter, and suggests that the island deer mice have not occupied the ecological niches of other small rodents found on the mainland but not on the

island. Though deer mouse numbers in early spring may be only one-eighth of those in late August, numbers from one spring to another do not vary greatly.

On the other hand, snowshoe hares are famous for their boom-and-bust population cycles. With peaks coming regularly at about 10-year intervals, these cycles exhibit extreme swings in the far north, less pronounced ones in the southern part of hare range (which includes Isle Royale). Like rabbits, hares have a high reproductive potential, and variations in the reproductive rate, influenced by availability of nutrients, seem the prime reason for fluctuations in the hare population. Diseases and predation are factors in the downward part of the cycle.

The flicker and other woodpeckers help to keep insect populations within bounds.

Predators that depend on hares are forced to take the same population roller-coaster ride. On Isle Royale, red fox numbers seem to peak about one year behind hare peaks, though careful estimates of the fox population have not been attempted. If the lynx, now rare or absent on the island, were more common, its population swings could be expected to parallel those of the hare.

Insect populations, also, sometimes explode and then fade. The larch sawfly boomed early in this century, killed many larches (tamaracks), and then dwindled. The spruce budworm multiplied fast in the 1930's, causing concern for the firs, a chief winter food of moose, then also overabundant. But since that time the insect has quietly retreated. The outbreak of the large aspen tortrix in the 1970's may give another example of the normally temporary nature of such explosions. As with other animals, insect outbreaks are

eventually controlled by food supply, predators, disease, parasites, and weather, and by aspects of the species' life history.

What determines the relative stability or instability of populations? This is a complex question with no simple answer, but an important part of it lies in the diversity of species present. The more species present in an area, the more stable its populations are likely to be. This is so because fluctuations within individual species tend to cancel each other out, and because various species act as a check on or a food supply for others. If, for instance, Isle Royale had more species of small mammals, it probably could support more foxes, and more small mammals might reduce the swings in the fox population by providing more choice of food, and a more stable total supply, in the critical winter season. If, say, voles were on the island, their numbers might be high at a time when hares were scarce, thus allowing more foxes to survive the winter. The relative stability of wolf and moose numbers on the island, though the wolf is dependent on the moose and is its only predator, is an interesting exception to the principle.

As a rule, islands have fewer species of animals than do mainland areas of comparable size and habitats. This is true mainly because for many species islands are difficult to reach. And if an established species is somehow wiped out, it may be a long time before new colonists arrive to try again. On the mainland, migration from one area to another is much easier. A number of species of vertebrates, as we have seen, and perhaps hundreds of invertebrates that live on the north shore of Lake Superior are not found on Isle Royale. Perhaps if all these were present, animal numbers on the island would be somewhat more stable. Generally speaking, however, population fluctuations on Isle Royale do not seem appreciably greater than they are on the mainland.

However much or little they may fluctuate, the populations on Isle Royale are determined largely by the quantity and quality of vegetation. This is so because green plants, directly in the case of herbivores, and indirectly in the case of carnivores, supply virtually all the food for animals. Exactly which species and how many of each are present at any given time depend on the species available in the region, their particular food requirements, and a

Green plants, such as blueberry and bog rosemary, are the foundation of terrestrial food chains.

number of other factors, some of which we have just considered.

Green plants, in turn, depend on water, carbon dioxide, and the energy of sunlight to produce the sugar from which the compounds necessary to sustain life are built. Plants also require other mineral nutrients from the environment for their own maintenance. So the potential amount of vegetation on Isle Royale is controlled by the amount of incoming energy from the sun, the amount of moisture, and the mineral nutrients in the soil and air. The nutrients further determine the quality of the vegetation as food for animals. In northern coniferous forests the water percolating down through the soil carries much of the needed nutrient below the reach of plant roots, and the low rates of evaporation do not allow a counter-flow of minerals upward. This mineral deficiency, together with the lower amount of sunlight, results in less production of plant matter here than in the deciduous forests to the south, and considerably less than in tropical forests. The island's forests are, however, much more productive than arctic tundra, which suffers from greater deficiencies. And current research by a Yale University team suggests that Isle Royale supports more animal life than do many other parts of the northern forest at similar latitudes. They suspect that this can be attributed to the island's underpinning of basalt and sedimentary rocks, which contribute more of the essential minerals to the soil than does the granite that underlies large areas elsewhere.

The relationships between incoming energy, minerals, plants, and animals can be studied particularly well on islands because the water prevents much interchange with the surrounding region. On Isle Royale, for instance, the interdependencies of moose, wolf, and vegetation are much easier to study than they are in mainland areas because here the animals are virtually "penned in" by Lake Superior: their numbers are little affected by immigration and emigration. The added fact that nature is allowed to operate unhindered creates an outdoor ecological laboratory of exceptional value—one that has attracted scientists since the middle of the last century.

The breeding habitats of great blue herons have been greatly diminished except in protected environments such as Isle Royale.

What does Isle Royale tell us about our own relationships with nature? One clear message is that we should encourage diversity. For instance, we create potentially very unstable situations by devoting large areas to one crop, which can be devastated by a single insect species or disease. Such monocultures limit the animal life that can act as checks on exploding pest populations. And we never know when some obscure plant or animal may be needed to provide something required for the welfare of man or his environment. But the fundamental message is that man, like other animals, is ultimately controlled by his environment. If we do not stabilize our numbers, we face the unpleasant alternative of starvation, disease, and warfare. And if we continue to poison our environment, it will eventually poison us.

For the earth, too, is an island—an island in the sea of space. All that we have is here, finite, wrapped within our round shore.

All too soon our visit ends. We must board the boat or plane and return to our mainland life. But though we leave the island, the island does not leave us. For we carry away memories: of a bull moose feeding in an evening lake, of fog rising from a wild rock shore, of night talk around a warm fire. And perhaps we try to put it all together—to see what the island has meant to us.

For some, the scientist particularly, the island has meant a chance to study nature in a place where man intrudes but little, and isolation produces a unique ecological laboratory, a nearly closed system.

For most people, the island has meant a brief experience of wilderness—a glimpse of the primordial world and of oneself as a human animal in it. The wilderness value of Isle Royale calls, I think, for some discussion, because it is a fragile thing requiring careful protection. More than to any other national park, people go to Isle Royale primarily for a wilderness experience. Yet, embracing 200 square miles of land and water, it is a small place as national parks go. As more people come to enjoy its wilderness, each person's wilderness experience is diminished, since solitude is its central ingredient. Clearly, there are limits beyond which visitation must not go. What those limits should be, how they should be achieved, and how much freedom visitors should be allowed once they get to the park are questions the Park Service wrestles with and with which all Americans—the "owners" of Isle Royale—should be concerned. In both a psychological and an ecological sense, Isle Royale has a limited carrying capacity for people as well as for wildlife.

Stuart Perry, editor of the Adrian, Michigan, *Daily Telegram,* foresaw the problem in 1931, when he wrote, "[Isle Royale's] value lies in its solitude and primeval condition rather than in any natural wonders. If there were natural wonders, it might be the duty of the public to make them as accessible as possible, but in the circumstances I maintain that the duty of the park man-

agement should be to make the place as inaccessible as possible in order that its peculiar value and charm may be conserved." To some extent, this painful remedy will have to be applied.

Another important part of the Isle Royale experience is the opportunity it gives us to be human. In this basic situation, we learn again the simple joys of eating after hunger, getting warm after being cold, drying out after being soaked, or resting after a long day's hike. And we learn again the value of the individual. With pressures removed, fewer people around, and a dependence on those few in case of emergency, we recognize our need for each other and have the chance to know each other simply as unique human beings. The common experience of all these things creates a special fellowship.

Finally, living on Isle Royale even briefly gives us a rare chance to gain perspective on ourselves and our civilization. Somehow the remoteness and the difference of this place wipe out our old images and allow new ones to form against the simple, natural background around us.

And so we return to our man-made world, shocked by its concrete and cars, but knowing that the island remains—a contrast, a restorer, a measure of our civilization.

Appendix

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The following list includes the common and scientific names of fungi, mosses, lichens, and conifers and flowering plants other than trees that are mentioned in the text.

Alder, green	*Alnus crispa*
Alder, speckled	*Alnus rugosa*
American yew	*Taxus canadensis*
Beardmoss (old man's beard)	*Usnea* sp.
Bluebead-lily	*Clintonia borealis*
Blueberry	*Vaccinium angustifolium*
Bluejoint grass	*Calamagrostis canadensis*
Bog rosemary	*Andromeda glaucophylla*
Bracken fern	*Pteridium aquilinum*
Bracket fungus	*Pleurotus* spp. and others
Burreed	*Sparganium* spp.
Bush honeysuckle	*Diervilla lonicera*
Calopogon	*Calopogon pulchellus*
Canada dogwood	*Cornus canadensis*
Cattail	*Typha latifolia*
Clover	*Trifolium* spp.
Club-moss	*Lycopodium* spp.
Devil's-club	*Oplopanax horridum*
Fireweed	*Epilobium angustifolium*
Fringed polygala	*Polygala paucifolia*
Harebell	*Campanula rotundifolia*
Hazelnut	*Corylus cornuta*
Hepatica	*Hepatica triloba*
Horsetail	*Equisetum* spp.
Joe-Pye-weed	*Eupatorium maculatum*
Juneberry	*Amelanchier bartramiana* and *A. sanguinea*
Juniper, trailing	*Juniperus horizontalis*
Juniper, common	*Juniperus communis*
Labrador tea	*Ledum groenlandicum*
Ladies'-tresses	*Spiranthes romanzoffiana*

Large-leaved aster	*Aster macrophyllus*
Leatherleaf	*Chamaedaphne calyculata*
Loosestrife	*Lysimachia terrestris*
Ninebark	*Physocarpus opulifolius*
Northern naiad	*Naiad flexilis*
Orchid, calypso	*Calypso bulbosa*
Orchid, one-leaf rein	*Habenaria obtusata*
Pearly everlasting	*Anaphalis margaritacea*
Pitcher plant	*Sarracenia purpurea*
Pondweed	*Potamogeton* spp.
Raspberry	*Rubus* spp.
Red-berried elder	*Sambucus pubens*
Reindeer lichen	*Cladonia* spp.
Skunk cabbage	*Symplocarpus foetidus*
Sphagnum moss	*Sphagnum* spp.
Spikerush	*Eleocharis palustris*
Spotted coralroot	*Corallorhiza maculata*
Squashberry	*Viburnum edule*
Starflower	*Trientalis borealis*
Sundew	*Drosera* spp.
Sweetgale	*Myrica gale*
Thimbleberry	*Rubus parviflorus*
Three-toothed cinquefoil	*Potentilla tridentata*
Touch-me-not	*Impatiens biflora*
Twinflower	*Linnaea borealis*
Twisted-stalk	*Streptopus roseus*
Wild-lily-of-the-valley	*Maianthemum canadense*
Wild sarsaparilla	*Aralia nudicaulis*
Wild strawberry	*Fragaria virginiana*
Yellow pond lily	*Nuphar variegatum*

	Habitat	Occurrence
Balsam fir, *Abies balsamea*	Near Lake Superior shore and on moist sites inland.	Very common
White spruce, *Picea glauca*	Most of island, decreasing toward southwestern uplands.	Very common
Black spruce, *Picea mariana*	In swamps and bogs. Occasional on dry sites.	Common
Larch (tamarack), *Larix laricina*	Swamps and bogs.	Formerly common, now rather scarce
White pine, *Pinus strobus*	Scattered throughout island. Generally considered a successional species, but may remain in mature forests for a long time. Some individuals live 300 or 400 years.	
Red pine, *Pinus resinosa*	Scattered in a few small stands on dry sites.	
Jack pine, *Pinus banksiana*	On ridgetops, rocky slopes, and other dry sites.	Fairly common
Northern white-cedar (arborvitae), *Thuja occidentalis*	Along harbors, bays, lake shores, swamps, and moist places inland. Found sparingly on drier sites. Prefers alkaline soil.	Common
Balsam poplar, *Populus balsamifera*	On beaches and old beach lines.	Fairly common
Quaking aspen, *Populus tremuloides*	A successional species found on all parts of the island.	Very common
Large-toothed aspen, *Populus grandidentata*	A successional species in the maple-birch forest area.	Uncommon
American hophornbeam, *Ostrya virginiana*	Reported only from the central part of Greenstone Ridge.	Very rare

	Habitat	Occurrence
Paper birch, *Betula papyrifera*	A successional species on all parts of the island.	Very common
Yellow birch, *Betula lutea*	Upland areas on southwestern third of island.	Common
Northern red oak, *Quercus rubra*	Considered a successional species in the maple-birch forest. Restricted largely to Greenstone Ridge between Mt. Ojibway and Sugar Mountain and to Red Oak Ridge.	Uncommon
American mountain-ash, *Sorbus americana*	Occurs primarily in spruce-fir forest areas, particularly in openings, at forest edge, and along the lakeshore. (Not an ash, but a member of the rose family.)	Fairly common
Common Apple, *Pyrus malus*	At Daisy Farm. Escaped from cultivation.	
Chokecherry, *Prunus virginiana*	A shrub or small tree, in open areas and forest edge.	
Fire cherry, *Prunus pensylvanica*	A shrub or small tree, widespread in woods, burns and openings. Heavily suppressed by moose browsing.	
Sugar maple, *Acer saccharum*	A principal species on ridges on southwestern third of island. Occurs on Greenstone Ridge northeast to Mt. Ojibway area.	
Red maple, *Acer rubrum*	On high ridges. Does not grow very tall.	Common
Striped maple, *Acer pensylvanicum*	Small, slender tree, last reported in 1908 by W. P. Holt as "rare on the island."	

	Habitat	Occurrence
Mountain maple, *Acer spicatum*	Tall shrub or small bushy tree in moderately shaded forest.	Common
White ash, *Fraxinus americana*		Rare if at all present
Black ash, *Fraxinus nigra*	On wet sites.	Fairly common

The following list is taken from O. L. Wallis, 1966, *Long Range Aquatic Resources Management Plan, Isle Royale National Park, 1966–1975.*

Oligotrophic lakes are deep, cold, and clear, with low nutrient levels and small amounts of plankton (microscopic plants and animals). Eutrophic lakes are shallower (to 10 feet), warm, and colored, with high nutrient levels, abundant plankton, and much aquatic vegetation. Dystrophic lakes are the shallowest (usually less than 5 feet), warm, and brown, with high nutrient levels, abundant plankton, and vegetation established in the shallow water around the entire shore.

Where a species has been recorded in only one lake of a given biological type, that lake is named. A dot indicates that it has been found in more than one lake of that type.

Symbols: *–non-native, †–not recently reported, **boldface**–forms restricted to Isle Royale	Lake Superior	Oligotrophic lakes	Eutrophic lakes	Dystrophic lakes	Unclassified lakes
*Sea lamprey, *Petromyzon marinus*	•				
Lake sturgeon, *Acipenser fulvescens*	•				
Alewife, *Alosa pseudoharengus*	•				
Lake Desor cisco, *Coregonus artedii* spp.		Desor			
Lake Superior cisco (herring), *Coregonus artedii arcturus*	•				
Sargent Lake cisco, *Coregonus artedii sargenti*		Sargent			
Siskiwit Lake cisco, *Coregonus bartletti*		Siskiwit			
Shortjaw cisco, *Coregonus zenithicus*	•				
Bloater, *Coregonus hoyi*	•				
Kiyi, *Coregonus kiyi*	•				
Superior blackfin cisco (bluefin), *Coregonus nigripinnis cyanopterus*	•				
Great Lakes whitefish, *Coregonus clupeaformis clupeaformis*	•				
Inland lakes whitefish, *Coregonus clupeaformis neohantoniensis*		Siskiwit			

Symbols: *–non-native, †–not recently reported, **boldface**–forms restricted to Isle Royale	Lake Superior	Oligotrophic lakes	Eutrophic lakes	Dystrophic lakes	Unclassified lakes
Lake Desor whitefish, *Coregonus clupeaformis dustini*		Desor			
Round whitefish (menominee), *Prosopium cylindraceum quadrilaterale*	●				
Pigmy whitefish, *Prosopium coulteri*	●				
*Rainbow trout (steelhead), *Salmo gairdneri irideus*	●				
†Brown trout, *Salmo trutta*	●				
Brook trout (coaster—lake-run form), *Salvelinus fontinalis*	●	●			Hatchet
Lake trout, *Salvelinus namaycush namaycush*	●	Siskiwit			
Siscowit, *Salvelinus namaycush siscowet*	●				
*American smelt, *Osmerus eperlanus mordax*	●				
White sucker, *Catostomus commersoni commersoni*	●	●	●	●	
Longnose sucker, *Catostomus catostomus catostomus*	●				
Creek chub, *Semotilus atromaculatus atromaculatus*					Hatchet
Northern pearl dace, *Semotilus margarita nachtriebi*		Desor	Forbes		Hatchet
Harvey Lake pearl dace, *Semotilus margarita koelzi*					Harvey
Lake chub, *Hybopsis plumbea*	●	Desor			
Longnose dace, *Rhinichythys cataractae*	●				
Finescale dace, *Chrosomus neogaeus*	●			●	Benson
Northern redbelly dace, *Chrosomus eos*	●			Wallace	
Golden shiner, *Notemigonus crysoleucas auratus*	●	●	●		Beaver
Emerald shiner (intergrade), *Notropis atherinoides acutus* X *N. a. atherinoides*	●	Siskiwit			

Symbols: *–non-native, †–not recently reported, **boldface**–forms restricted to Isle Royale	Lake Superior	Oligotrophic lakes	Eutrophic lakes	Dystrophic lakes	Unclassified lakes
Northern spottail shiner, *Notropis hudsonius hudsonius*	•	•	•		Beaver Chickenbone Hatchet Whittlesey
Blackchin shiner, *Notropis heterodon*	•				
Northern mimic shiner, *Notropis volucellus volucellus*	•	Richie			
Northern blacknose shiner, *Notropis heterolepis heterolepis*	•	•	•	•	Beaver Benson
Harvey Lake blacknose shiner, *Notropis heterolepis regalis*					Harvey
Northern fathead minnow, *Pimephales promelas promelas*	•			•	Hatchet
Harvey Lake fathead minnow, *Pimephales promelas harveyensis*					Harvey
Northern pike, *Esox lucius*	•	•	•	•	Beaver Benson Chickenbone George Whittlesey
†Muskellunge, *Esox masquinongy*	•				
Burbot (lawyer), *Lota lota*	•	Siskiwit			
Trout perch, *Percopsis omiscomaycus*	•	•			Hatchet Whittlesey
Yellow perch, *Perca flavescens*	•	•	•	•	Beaver Benson Chickenbone George Harvey Whittlesey
Walleye, *Stizostedion vitreum vitreum*	•		Dustin		Chickenbone Whittlesey
Northern logperch, *Percina caprodes semifasciata*	•	Siskiwit	Dustin		Whittlesey
Iowa darter, *Etheostoma exile*		Sargent			Chickenbone

Symbols: *–non-native, †–not recently reported, **boldface**–forms restricted to Isle Royale	Lake Superior	Oligotrophic lakes	Eutrophic lakes	Dystrophic lakes	Unclassified lakes
Pumpkinseed, *Lepomis gibbosus*	•	Richie	Mason		
*Black crappie, *Pomoxis nigromaculatus*	•				
Fourhorn sculpin, *Myoxocephalus quadricornis thompsoni*	•				
Spoonhead sculpin, *Cottus ricei*	•	•			Whittlesey
Mottled sculpin, *Cottus bairdi*	•				Chickenbone
Slimy sculpin, *Cottus cognatus*	•	•	Mason		Chickenbone
Brook stickleback, *Culea inconstans*	•	•		•	Harvey Hatchet
Ninespine stickleback, *Pungitius pungitius*	•	•			Hatchet

	Habitat	Occurrence
Mudpuppy, *Necturus maculosus*	Lakes and streams.	?
Blue-spotted salamander, *Ambystoma laterale*	Forest, under logs and leaves.	?
Red-spotted newt, *Diemictylus viridescens*	Shallow water, forest.	?
American toad, *Bufo terrestris*	Most land environments; breeds in water.	Common
Spring peeper, *Hyla crucifer*	Shrubby vegetation; breeds in water.	Common
Western chorus frog, *Pseudacris nigrita triseriata*	Rock pools, bogs, and swamps.	Common (rock pools)
Wood frog, *Rana sylvatica*	Moist woods and streams.	Common
Green frog, *Rana clamitans*	Most aquatic environments.	Common
Mink frog, *Rana septentrionalis*	Aquatic environments.	?
Painted turtle, *Chrysemys picta*	Beaver ponds and small lakes.	Uncommon
Garter snake, *Thamnophis sirtalis*	Most land environments.	Common
Red-bellied snake, *Storeria occipitomaculata*	Moist land environments.	Uncommon

The following information, with a few additions and changes, is from *Birds of Isle Royale in Lake Superior*, by L. Krefting, F. B. Lee, P. C. Shelton, and K. T. Gilbert, Bureau of Sport Fisheries and Wildlife, Special Scientific Report—Wildlife No. 94, 1966.

Key to habitat types: 1/ Sugar maple-yellow birch climax forest; 2/Spruce-fir-birch climax forest; 3/ Aspen-birch-conifer forest; 4/ Aspen-birch (1936 burn); 5/ Swamp forest; 6/ Open areas; 7/ Riparian brush; 8/ Beaver ponds and streams; 9/Inland lakes, ponds, and sheltered harbors; 10/ Lake Superior; 11/ Lake shore, beaches, small islands, and rocky reefs.

Species	Habitat type	Rare	Permanent resident	Summer resident	Winter resident	Migrant
Common loon	9/10/11			common		common
Red-throated loon	10	•				
Red-necked grebe	9/10					uncommon
Horned grebe	9/10					common
Pied-billed grebe	9/10			uncommon		uncommon
White pelican	9					rare
Double-crested cormorant	9/10/11			uncommon		uncommon
Great blue heron	8/9/11			uncommon		common
Green heron		•				
American bittern	8/9			uncommon		
Mute swan		•				
Whistling swan	9					rare
Canada goose	9					common
Snow goose						uncommon
Blue goose	9					rare
Mallard	8/9/11			uncommon		uncommon
Black duck	8/9/11			common		
Gadwall		•				
Pintail	9					rare
Green-winged teal	8/9			uncommon		

Species	Habitat type	Rare	Permanent resident	Summer resident	Winter resident	Migrant
Blue-winged teal	8/9			uncommon		uncommon
American widgeon	8	•				
Shoveller		•				
Wood duck	8			uncommon		
Redhead		•				
Ring-necked duck	8/9			uncommon		
Greater scaup	9					common
Lesser scaup	9					common
Common goldeneye	9/10/11			common		common
Bufflehead	9/10					common
Oldsquaw	10					common
White-winged scoter	10					common
Surf scoter		•				
Common scoter	10					rare
Ruddy duck		•				
Hooded merganser	8/9/11			uncommon		common
Common merganser	9/10/11			common		common
Red-breasted merganser	9/10/11			common		
Goshawk	2/3/4/5			rare	uncommon	
Sharp-shinned hawk	2/3/4/6			uncommon		common
Cooper's hawk	3/4/6/11			uncommon		uncommon
Red-tailed hawk	1/3/4/6			uncommon		
Red-shouldered hawk	1/4/6			rare		
Broad-winged hawk	1/2/3			common		common
Rough-legged hawk						uncommon
Golden eagle		•				
Bald eagle	1/2/3/4/9/10			rare		
Marsh hawk	4/6			uncommon		uncommon
Osprey	2/5/9/11			uncommon		
Gyrfalcon					rare	
Peregrine falcon	11			rare		
Pigeon hawk	2/6/9/11			uncommon		rare
Sparrow hawk	4/6			common		common
Sharp-tailed grouse	3/4/6		uncommon			

Species	Habitat type	Rare	Permanent resident	Summer resident	Winter resident	Migrant
Virginia rail		•				
Sora	8			uncommon		uncommon
American coot	9/10					rare
Semipalmated plover	11	•				
Killdeer	6/11			uncommon		uncommon
Black-bellied plover	11					uncommon
American woodcock	3/4/6/7			uncommon		
Common snipe	7/11			rare		uncommon
Whimbrel						rare
Spotted sandpiper	9/11			common		
Solitary sandpiper	8/9/11			rare		uncommon
Greater yellowlegs	11	•				
Lesser yellowlegs	11	•				
Least sandpiper	9/11	•				
Semipalmated sandpiper		•				
Sanderling	11	•				
Herring gull	9/10/11			common		
Ring-billed gull	9					uncommon
Bonaparte's gull	9/10					uncommon
Common tern	10	•				
Caspian tern	10					rare
Mourning dove						rare
Yellow-billed cuckoo	4/6/11			rare		rare
Black-billed cuckoo	4/6/11			rare		
Great horned owl	1/2/3/5		uncommon			
Snowy owl	4/11				uncommon	
Hawk owl	2		rare			
Long-eared owl		•				
Short-eared owl	6	•				
Saw-whet owl		•				

Species	Habitat type	Rare	Permanent resident	Summer resident	Winter resident	Migrant
Whippoorwill	6			rare		
Common nighthawk	4/6/8			common		
Chimney swift	1/2/4/11			uncommon		
Ruby-throated hummingbird	6/7/8			uncommon		
Belted kingfisher	8/9/11			common		
Yellow-shafted flicker	3/4/6/8			common		common
Pileated woodpecker	1/2/3		uncommon			
Red-headed woodpecker		•				
Yellow-bellied sapsucker	2/3/5			uncommon		
Hairy woodpecker	1/2/3/5		common			
Downy woodpecker	1/2/3/4		common			
Black-backed three-toed woodpecker	2/3		rare			
Northern three-toed woodpecker	2/3					rare
Eastern kingbird	4/8			common		
Eastern phoebe	6/8/11			uncommon		common
Yellow-bellied flycatcher	3/5/7			uncommon		
Traill's flycatcher	3/6/7			uncommon		
Least flycatcher	2/3/6/7			uncommon		common
Eastern wood pewee	1/3			uncommon		uncommon
Olive-sided flycatcher	4/5			uncommon		
Horned lark	6/11					common
Tree swallow	8/9/11			common		
Bank swallow	11	•				
Barn swallow	6/11			uncommon		
Cliff swallow	11			rare		
Purple martin		•				
Gray jay	2/3/4/5/6		common			
Blue jay	1/2/3/4/5/6		common			
Common raven	2/3/4/5/6		uncommon			
Common crow	2/3/4/5/6			common		

Species	Habitat type	Rare	Permanent resident	Summer resident	Winter resident	Migrant
Black-capped chickadee	1/2/3/4/5/6		common			
Boreal chickadee					rare	
White-breasted nuthatch	1/2			rare		
Red-breasted nuthatch	2/3/5		common			
Brown creeper	2/3/5			uncommon		
House wren				rare		
Winter wren	1/2/3/5/11			common		
Short-billed marsh wren	7/8			uncommon		
Mockingbird		•				
Catbird	7			rare		
Brown thrasher	3/4			rare		
Robin	3/4/6			uncommon		common
Wood thrush				rare		
Hermit thrush	2/3			uncommon		
Swainson's thrush	2/3			common		
Gray-cheeked thrush						uncommon
Veery	2/3/5			uncommon		
Eastern bluebird	3/6			uncommon		
Golden-crowned kinglet	2/3/5			uncommon		common
Ruby-crowned kinglet	2/3/5			uncommon		common
Water pipit	6/11					uncommon
Cedar waxwing	3/4/6/11			common		
Northern shrike	3/6				rare	uncommon
Loggerhead shrike		•				
Starling	4/6/8			uncommon		

Species	Habitat type	Rare	Permanent resident	Summer resident	Winter resident	Migrant
Yellow-throated vireo		•				
Solitary vireo	2/3/4			uncommon		
Red-eyed vireo	2/3			common		
Philadelphia vireo		•				
Warbling vireo		•				
Black and white warbler	2/3			uncommon		uncommon
Tennessee warbler	2/3			rare		common
Orange-crowned warbler	3/4/6					uncommon
Nashville warbler	3/4/6			common		common
Parula warbler	2/7			uncommon		
Yellow warbler	7			rare		rare
Magnolia warbler	2/3			common		
Cape May warbler	2/3/5/6			rare		common
Black-throated blue warbler	1/3/5			common		
Myrtle warbler	2/3/11			common		common
Black-throated green warbler	1/2/3			common		
Blackburnian warbler	1/2/3			common		
Chestnut-sided warbler	3/4/6			common		
Bay-breasted warbler	2/3			rare		uncommon
Blackpoll warbler	2/3			rare		uncommon
Pine warbler						
Palm warbler	2/3/4/6/8/11					common
Ovenbird	1/2/3/4			common		
Northern waterthrush	8/11			uncommon		uncommon
Connecticut warbler	3/6			rare		uncommon
Mourning warbler	3/4/6			common		
Yellowthroat	7/8			uncommon		uncommon
Wilson's warbler	2/6/7					common
Canada warbler	3/7			uncommon		
American redstart	3/7			uncommon		
House sparrow	6	•				
Bobolink	6			rare		rare
Eastern meadowlark	6					rare
Redwinged blackbird	6/7/8/9/11			common		

Species	Habitat type	Rare	Permanent resident	Summer resident	Winter resident	Migrant
Baltimore oriole						rare
Rusty blackbird	6/11					common
Brewer's blackbird	11					rare
Common grackle	6/8			common		
Brown-headed cowbird	6/8/11			uncommon		common
Scarlet tanager	2/3/5/6			uncommon		uncommon
Rose-breasted grosbeak	3			uncommon		uncommon
Indigo bunting	6			uncommon		uncommon
Evening grosbeak	6			uncommon	uncommon	uncommon
Purple finch	2/3/5			uncommon	uncommon	
Pine grosbeak	2/3/6			rare	uncommon	
Common redpoll	2/3				common	
Pine siskin	2/3/5/6			uncommon	common	common
American goldfinch	6			uncommon	uncommon	uncommon
Red crossbill	2/3/5			uncommon	uncommon	uncommon
White-winged crossbill	2/3/5			uncommon	uncommon	uncommon
Rufous-sided towhee		•				
Savannah sparrow	6			uncommon		common
Vesper sparrow	6			uncommon		common
Lark sparrow		•				
Slate-colored junco	2/3/4/6			uncommon		common
Tree sparrow	6					uncommon
Chipping sparrow	2/3/6			uncommon		common
Clay-colored sparrow	6					uncommon
Field sparrow		•				
Harris' sparrow	4/6					rare
White-crowned sparrow	4/6					uncommon
White-throated sparrow	4/5/6/7/11			common		
Fox sparrow	6					uncommon
Lincoln's sparrow	6/7			uncommon		common
Swamp sparrow	6/7/11			common		
Song sparrow	6/7/11			common		
Lapland longspur	6/11					uncommon
Snow bunting	6/11				rare	common

	Habitat	Occurrence
Little brown myotis, *Myotis lucifugus*		?
Keen myotis, *Myotis keenii*		?
Big brown bat, *Eptesicus fuscus*		?
Short-tailed weasel, *Mustela erminea*	Most land environments.	Rare
Mink, *Mustela vison*	Streams, lakes, forests.	Uncommon
River otter, *Lutra canadensis*	Streams, lakes, harbors.	Rare
Red fox, *Vulpes fulva*	All land environments.	Common
Gray wolf, *Canis lupis*	All land environments.	Uncommon
Lynx, *Lynx canadensis*	Land environments.	Rare (possibly intermittently absent)
Red squirrel, *Tamiasciurus hudsonicus*	Forests.	Common
Beaver, *Castor canadensis*	Streams, ponds, lakes, harbors.	Common
Deer mouse, *Peromyscus maniculatus*	Most land environments.	Common
Muskrat, *Ondatra zibethicus*	Streams, ponds, lakes.	Uncommon
Snowshoe hare, *Lepus americanus*	Most land environments.	Common
Moose, *Alces alces*	All land environments, ponds, lakes, harbors.	Common
Marten, *Martes americana*		?
Coyote, *Canis latrans thamnos*		Formerly present
White-tailed deer, *Odocoileus virginiana*		Formerly present
Woodland caribou, *Rangifer tarandus*		Formerly present
Norway rat, *Rattus norvegicus*		Formerly present

Oligotrophic lakes are deep, cold, and clear, with low nutrient levels and small amounts of plankton (microscopic plants and animals). Eutrophic lakes are shallower (to 10 feet), warm and colored, with high nutrient levels, abundant plankton, and much aquatic vegetation. Dystrophic lakes are the shallowest (usually less than 5 feet), warm, and brown, with high nutrient levels, abundant plankton, and vegetation established in the shallow water around the entire shore.

	Area in acres	Maximum depth in feet	Biological character
Ahmik	24	10	Dystrophic
Amygdaloid	40		Eutrophic
Angleworm	120	30	Eutrophic
Beaver	42	17	
Benson	50	14	
Chickenbone	237	21	
Desor	1050	55	Oligotrophic
Dustin	9	22	Eutrophic
Epidote	3	5	Eutrophic
Eva	32	24	Eutrophic
Feldtmann	461	10	Eutrophic
Forbes	16	21	Eutrophic
George	7½	10	
Halloran	187	10	Eutrophic
Harvey	137	13	
Hatchet	131	18	
Hidden	3		Dystrophic

	Area in acres	Maximum depth in feet	Biological character
Intermediate	162	24	Eutrophic
John	9	14	Eutrophic
LeSage	106	30	Eutrophic
Lily	14		Dystrophic
Linklater	40	21	Eutrophic
Livermore	80	19	Eutrophic
Mason	50	26	Eutrophic
McDonald	30	14	Eutrophic
Moose	5½		Dystrophic
Mud	50	3	Dystrophic
Newt	15		Dystrophic
Ojibway	40		
Otter	43	14	Eutrophic
Patterson	20	13	Eutrophic
Richie	520	39	Oligotrophic
Sargent	368	45	Oligotrophic
Shesheeb	25½	20	Eutrophic
Scholts	5½	5	Eutrophic
Siskiwit	4500	142	Oligotrophic
Stickleback	3		Dystrophic
Sumner	22		Dystrophic
Theresa	13		Dystrophic
Wagejo	14	10	Eutrophic
Wallace	8		Dystrophic
Whittlesey	156	30	

About the author:

Napier Shelton, a lifelong resident of Washington, D.C., is a dedicated naturalist with a special interest in birdwatching. He holds an M.A. in plant ecology from Duke University and a Ph.D. in geography from the University of Michigan.

Diagrams

By Betty Fraser, based on drawings by Robert Johnsson.

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